ISSN 0377-9335

ENTOMON

Vol. 22 June 1997 No. 2

CONTENTS

ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
Department of Zoology, University of Kerala
Kariavattom, Trivandrum, India 695581

ENTOMON

ENTOMON is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other arthropods.

Address MS and all editorial correspondence to Managing Editor, ENTOMON, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695581, India.

SUBSCRIPTION RATES

Annual subscription for Institutions: Rs. 400.00 (in India); US$ 120.00 (Air Mail)
Annual subscription for individuals: Rs. 150.00 (in India); US$ 60.00 (Air Mail)

1. All remittance to the Journal or Association should be sent to the Secretary-Treasurer of the Association by Bank Draft only, A/c payee in favour of the Association for Advancement of Entomology.
2. Requests for replacement copies of ENTOMON in lieu of numbers lost in transit, should reach the Secretary-Treasurer not later than three months after the date of publication of the number.

ENTOMON is covered in the following abstracting/indexing journals: *Chemical Abstracts, Review of Applied Entomology, Science Citation Index* and *Current Contents/Agriculture, Biology* and *Environmental Sciences, Biological Abstracts, Entomology Abstracts* and other relevant abstracts, *Referativny Zhurnal* and *Current Advance in Biological Sciences*.

Entomon 22(2): 89–93 (1997)

Simple Method to Purify Polyhedral Inclusion Bodies from *Nosema* (Microspora: Nosematidae) Contamination

S. Sudhakar,[1] R. Varatharajan[2] and S. Mathavan[1]*

[1]*Department of Genetics, School of Biological Sciences, Madurai Kamaraj University Madurai 625021, India*

[2]*Department of Life Sciences, Manipur University, Manipur 795003, India*

Abstract: The cotton boll worm *Helicoverpa armigera* is infected by Nucleo Polyhedrosis Virus (NPV) and microsporidian namely *Nosema* sp. The co occurance of these pathogens in the infected *H. armigera* larvae have been confirmed by simple staining technique and also by electron microscopical studies. PIBs are normally purified by sucrose gradient ultracentrifugation. However, the sucrose gradient method could not eliminate the microsporidian contamination from PIBs. Extraction of viral DNA from the PIBs contaminated with nosema has resulted in the shearing of viral DNA. This paper reports a simple method to purify PIBs from *Nosema* contamination. This technique does not require ultracentrifugation for the purification of PIBs and to extract good quality of viral DNA.

Keywords: Purification, NPV, *Nosema, Helicoverpa armigera.*

INTRODUCTION

Purification of Polyhedral Inclusion Bodies (PIBs) of baculovirus from the infected larvae is usually carried out by the standard technique (O'Reilly *et al.*, 1992). It essentially involves putrification of the virus infected dead larvae in distilled water, filtration, and differential centrifugation. The PIBs were pelleted and gently washed with SDS (0.5% final concentration), followed by water wash and finally subjected to sucrose gradient ultracentrifugation (SGUC). Viral DNA was extracted from the gradient purified PIBs following alkali lysis, proteinase-K treatment and phenol-chloroform method (Miller and Dawes, 1978). When the above procedures were followed to extract viral DNA from the PIBs of *H. armigera* Nucleo Polyhedrosis Virus (HaNPV), shearing of DNA was encounted when the PIBs were contaminated with the microsporidians namely *Nosema* sp. (Microspora: Nosematidae). It is well known that both nosema and baculovirus infect a number of insects (Weiser, 1977) and the cotton boll worm *H. armigera* is not an exemption to the above pathogens (Jayaraj *et al.*, 1988). Since, the viral DNA extracted from PIBs mixed microsporidians resulted in shearing of the

Received in May, 1997. *Corresponding author

DNA, a simple method has been developed to purify PIBs from nosema contamination. DNA extracted from the purified PIBs was clean and showed perfect restriction pattern.

MATERIALS AND METHODS

To find out the presence of nosema among the cluster of PIBs, 20μl of the sample from the infected larvae was diluted to 1 ml with water. Few drops of Sudan Black stain were added (Humason, 1979) and observed under oil immersion in light microscope.

Purification of PIBs without ultracentrifugation

H. armigera larvae infected with NPV and the microsporidians were allowed to putrify and the putrified sample were subjected to filtration through cheese cloth. Crude filtrate was initially subjected to differential centrifugation at 1300 rpm for 60 seconds and the supernatant was collected and then centrifuged at 5000 rpm for 10 minutes so as to pellet down the PIBs. This pellet contained both PIBs and nosema. The pellet was washed with water and subjected to SDS treatment (2% final concentration) at room temperature for 4 hours. The solution was periodically mixed by shaking vigorously. Later it was centrifuged at 5000 rpm for 10 minutes. The pellet was subjected to SDS treatment twice as described. Later the pellet was washed with distilled water three times; dissolved in distilled water and stored at $-20°C$. Pure, milky white HaNPV PIBs were obtained by this method.

Electron microscopy

The PIBs purified following the procedure described in this paper were dehydrated in an ethanol series. Samples were air dried separately on the grid and processed for electron microscopy as described by Adams and Wilcox (1982). The samples were examined and photographed in Joel Scanning electron microscope.

Viral DNA extraction and restriction analysis

The PIBs were lysed with 0.1M Na_2CO_3 in the presence of 1% SDS at 37°C for 30 mins with occasional gentle mixing. The sample was spun at 10,000 rpm for 5 mins. The virus containing supernatant was digested with 100 μg/ml proteinase-K at 50°C for 12 hrs. The sample was subjected for DNA extraction following the method of O'Reilly *et al.*, (1994) and the DNA was suspended in TE pH 8. Viral DNA extracted was digested with Bgl I and subjected to electrophoresis following standard protocol (Sambrook *et al.*, 1989).

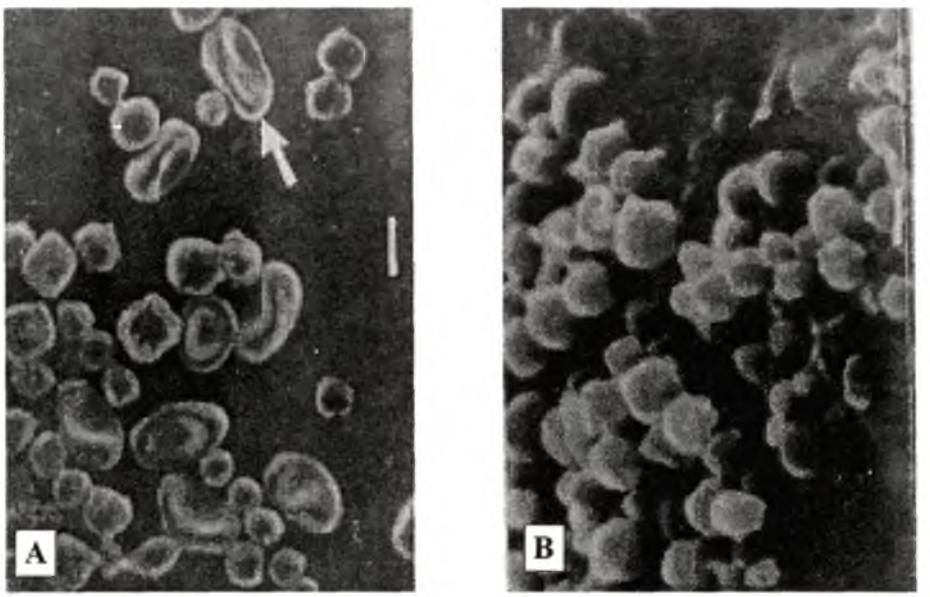


Fig. 1A: SEM picture showing PIBs of HaNPV contaminated with nosema, purified following SGUC technique. Arrow mark denotes nosema; spherical bodies are PIBs of HaNPV. Bar represents one μm.
Fig. 1B: SEM picture showing purified PIBs of HaNPV following present method without SGUC technique. Absence of nosema contamination is evident in this electron micrograph. Bar represents one μm.

RESULT AND DISCUSSION

Table 1
Density of *Nosema* in PIBs suspension of HaNPV after SDS treatment

Treatment	No/ml
Control (Water-wash and Centrifugation)	11.04×10^{6}a
Sucrose Gradient UltraCentrifugation (SGUC) 10-80%	10.16×10^{6}a
Sonication (120 Hz for 30 sec. for three times)	08.44×10^{6}a
SDS treatment (2% final concentration)	02.90×10^{4}b
Critical Difference at 5% level	02.72×10^{6}

Figures followed by the same letter in the last column are not significantly different at 5% level (ANOVA)

In the infected larval samples, presence of the PIBs and nosema were observed under the light microscope. On staining they were visible distinctly with a prominent

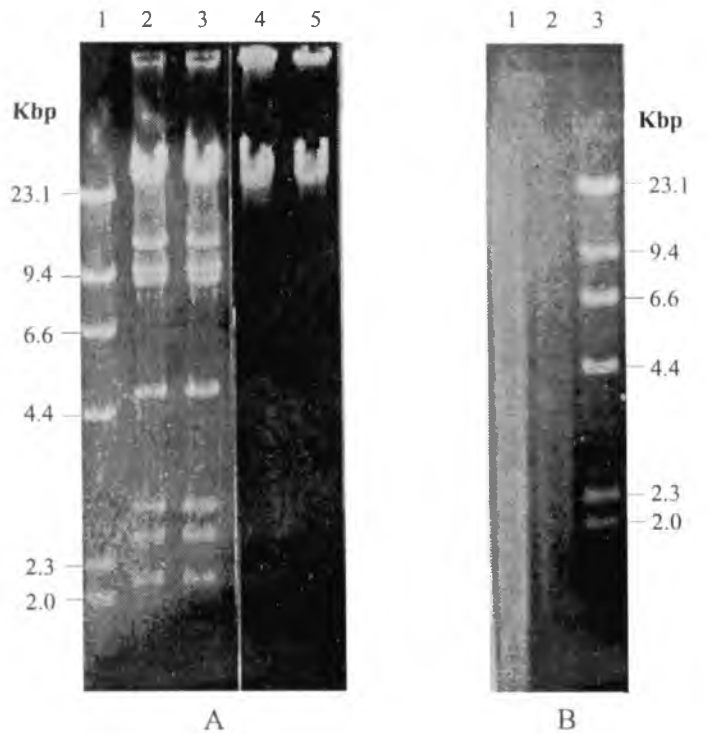


Fig. 2A: Lane 1. λ DNA digested with Hind III (marker). Lane 2. HaNPV DNA digested with Bgl I (the PIBs were purified using present technique). Lane 3. HaNPV DNA digested with Bgl I (the PIBs were purified using present technique, followed by SGUC). Lane 4. HaNPV DNA undigested (the PIBs were purified using present technique). Lane 5. HaNPV DNA undigested (the PIBs were purified using present tecnhique, followed by SGUC).
Fig. 2B: Lane 1. HaNPV DNA undigested (PIBs contaminated with nosema, purified by SGUC technique). Lane 2. HaNPV DNA digested with Bgl I (PIBs contaminated with nosema, purified by SGUC technique). Lane 3. λ DNA digested with Hind III (marker)

green body at the centre being surrounded by yellowish outer membrane. The co-occurrence of PIBs and nosema was also confirmed by EM studies (Figure 1A). On observation, nosema appeared elliptical (2-3μm diameter, 4-5μm length), while PIBs were spherical (0.6–2.3μm in diameter) in shape at low magnification. The mean density of nosema was found to be 11.4×10^6 per ml and that of PIBs being 38×10^6 per ml in the sample analysed. Sonication of the sample or O'Reilly *et al.*, (1992) procedure of PIB purification did not reduce the density of nosema (Table 1). Significant reduction (P=0.05) in the density of nosema contamination was observed after SDS treatment (Table 1) and this was also evident in the electron microscopic analysis (Figure 1B). However, negligible density of nosema was found with PIBs after the SDS treatment and this density did not affect the process of viral DNA extraction or the quality of viral DNA. DNA extracted from the PIBs purified following the present method and that purified using SGUC technique (from uncontaminated PIBs) were of same quality (Figure 2A; Lane 2 and 3). Clear restriction pattern was obtained with

the DNA extracted from PIBs either with or without SGUC (Figure 2A; Lane 2 and 3).

It is evident from the figure that SGUC technique is not essential for PIBs purification to get good quality of viral DNA. However, the DNA extracted from nosema contaminated PIBs were sheared on agarose gel and could not be used for restriction analysis (Figure 2B; Lane 1 and 2). This method shows that simple SDS treatment can substantially reduce nosema contamination so as to get clear PIBs which would result in the yield of good quality of viral DNA. Further, laboratories which do not have the Ultracentrifugation facility can follow this method to purify PIBs and to extract viral DNA.

ACKNOWLEDGEMENTS

We thank Mr. R. Ashokan (Scientist in Indian Institute of Horticultural Research, Bangalore) and Dr. Shivaprasad (Central Sericultural Research and Training Institute, Mysore) for identifying the microsporadian. We also thank Prof. G. Kulandhaivelu, (M. K. University) for EM work. The authors, S. Sudhakar is grateful to CSIR and Dr. S. Mathavan and Dr. R. Varatharajan are thankful to DBT for financial support.

REFERENCES

Adams, J. R. and T. A. Wilcox (1982). Scanning Electron Microscopical comparisions of Insect Virus occlusion bodies prepared by Several Techniques. *J. inverteb Pathol.* **40**: 12–20.

Humason, L. G. (1972). Animal Tissue Techniques. 3rd edition, W. H. Freeman and Co. Sanfrancisco. pp 308.

Jayaraj, S., R. J. Rabindra and K. Narayanan (1988). Proc. Int. Workshop. Control of *Heliothis* far East Reg. Off. US, Dept of Agric. **3**: 18–20.

Miller, L. K. and K. P. Dawes (1978). Restriction endonulease analysis for the identification of baculovirus pesticides. Appl. Environ. Microbiol. **35**: 411–421.

O'Reilly, D. R., L. K. Miller and V. A. Lucknow (1992). Baculovirus Expression Vectors - A laboratory manual. W. H. Freeman and Company, New York. pp 347.

Sambrook, J., E. F. Fritschi and T. Maniatis (1989). Molecular cloning. A laboratory manual. 2nd edition. Cold Spring Harbour, New York. pp 6.9 - 6.19.

Weiser, J. (1977). An Atlas of Insect diseases. Academia Publishing House Czechoslovak. pp 240.

Entomon 22(2): 95–100 (1997)

Host-stage Selection and Preference for Oviposition of the Parasitoid *Dinarmus basalis* Rond. (Hymenoptera: Pteromalidae) on *Callosobruchus chinensis* L.

W. Islam*

Institute of Biological Sciences, Rajshahi University
Rajshahi, Bangladesh

Abstract: Selection of the host stages for oviposition of *Dinarmus basalis* for different developmental stages of *Callosobruchus chinensis* showed that the parasitoid deposited eggs on 2nd, 3rd and 4th instar larvae, pre-pupae and pupae but most preferred 4th instar larvae. Host selection is made by antennae and ovipositor. A significant difference in host stage preference for different developmental stages was observed ($P < 0.001$).

Keywords: *Dinarmus basalis*, ectoparasitoid, *Callosobruchus chinensis*, host-stage selection and preference.

INTRODUCTION

Dinarmus basalis Rond. is a cosmopolitan ectoparasitoid of larval, prepupal and pupal stages of the pulse beetle, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae) that develop inside kernels of stored lentil, *Lens esculentus* L. (Southgate 1979; Islam *et al.*, 1985). This parasitoid has only recently attracted attention as a biological control agent (Islam and Kabir 1995). However, host age is known to affect some life history characteristics, including fecundity, developmental time, and progeny sex ratio, in some parasitoids (Wylie 1964; Yoo and Ryoo 1989; King 1991; Heinz and Parrella 1990) including *D. basalis* (Islam 1994a), and this can affect host-parasitoid population dynamics (Bellows and Hassell 1988). Thus it is important to determine host-age selection or preference before conducting intensive life history studies.

D. basalis searches for the developmental stages of the host for oviposition. No published material on the host stage selection or preference of *D. basalis* is available. The purpose of this study was to determine host-stage selection or preference of *D. basalis* for oviposition on developmental stages of *C. chinensis*.

Received in February, 1997. *Corresponding author

MATERIALS AND METHODS

Twenty mated females of *C. chinensis* each were released in each different petri dishes containing lentil, *Lens esculentus* (L.) up to 2 h for egg laying and then removed. The egg laying seeds were left undisturbed in the incubator (30 ± 1°C) for development.

After 8, 10, 12, 14 and 16 days egg-containing seeds were removed randomly from the incubator. Eight day old seeds were soaked in water for 5-7 h. When the outer coats of the seeds became soft, the seeds were dissected to trace the presence of *C. chinensis* larvae. Subsequently, the 10, 12, 14 and 16 day old seeds were taken out from the petri dishes and dissected in the same way and were found to contain 3rd instar larvae, 4th instar larvae, pre-pupae and pupae respectively. Unmated 24 h old females of *D. basalis* were collected from the culture and confined with males and fed on honey for 24 h to increase their egg production.

Following behavioural components were studied on a tape recorder by putting *D. basalis* on seeds contains 2nd, 3rd and 4th instar larvae, pre-pupae and pupae of *C. chinensis* separately.

a. encountering host: The wasp encounters a host infested seed; the first contact is always made with antennae.

b. drumming the host: The wasp walks on the host infested seed, simultaneously drumming it with her antennae.

c. adopting oviposition posture: After the host infested seed has been drummed, the wasp tapped/adopt the oviposition posture: the abdomen is lowered until the tip of the ovipositor touches the surface of the seed. At this time, the body of the parasitoids vibrates vigorously and at the same time the sharp and pointed ovipositor is inserted forcibly into the seed by piercing through the outer coat. After this, the tip of the abdomen is turned towards right and left for 3 to 5 times and possibly during this act an egg is laid.

The biological meaning of host stage preference was studied by the following way: the infested seeds containing the different stages of *C. chinensis* were marked with different letters on the surface of the seeds. The signs were: no marking (2nd instar), V (3rd instar), O (4th instar), I (pre-pupae) and X (pupae).

A mated female was introduced in each petri dish containing 30 previously infested seeds of different ages. Each seed contains only one host. The petri dishes were placed in an incubator for 24 h for oviposition and for development after removing of the adult parasitoid. The number of emerged parasitoids was noted (2nd generation). Host stage preference was determined, by the number of parasitoids emerging from each host stage which was confirmed by the presence of emerging holes left on the seeds. Data were 25 female tested for each host stage.

RESULTS AND DISCUSSION

When a *D. basalis* female shows a normal oviposition-behaviour sequence the following phases encountering hosts, drumming host, adopting oviposition posture were observed. As I have shown in my previous study (Islam 1994b) host selection does not occur before the parasitoid drummed its host. Oviposition may be terminated prematurely. It appeared that sometimes the adoption of oviposition postures (of short

duration) did not result in actual egg deposition. This I defined as rejection after ovipositional test (as different from rejection after antennal test).

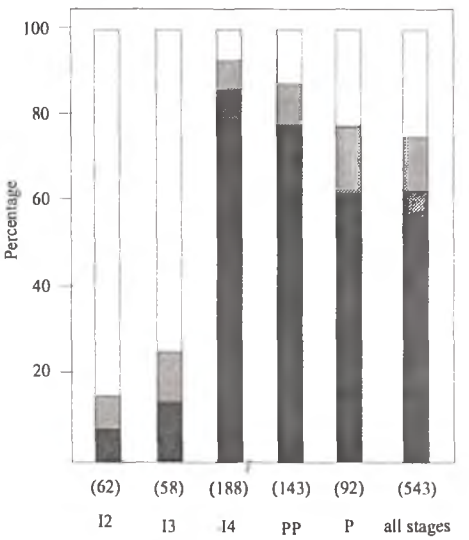


Fig. 1. Percentage rejection after antennal test (open column), percentage rejection after ovipositional test (hatched column) and percentage acceptance (solid column) of *Callosobruchus chinensis* stages by *Dinarmus basalis*. Between parantheses: The total number of contacts.

Table 1
Number of F_1 adult progeny emerged from different stages of *C. chinensis*

Host larval Instars/stages	No. observed	Range	Mean
3rd instar larvae	30	1–3	1.92c
4th instar larvae	30	4–7	5.44a
Pre-pupae	30	4–6	5.12a
Pupae	30	1–4	2.24b

*Figures followed by the same letters are not significantly different at 5% by the DMRT.

The data are summarized in Fig. 1. The total number of contacts with hosts of a certain stage is given under the columns. The upper part of the columns (white) gives the percentage rejection of hosts of a certain stage after antennal test. From these rejection percentages, I may conclude that the following preference sequence for the different host stages exists (from most to less accepted): instar 4, pre-pupa, pupa, instar 3, instar 2. The percentages of hosts rejected after ovipositional test (hatched part of the columns) vary only 7 to 26%.

The F_1 progeny emerging from the 3rd and 4th instar larvae, pre-pupae and pupae

of the host are summarized in Table 1. It was noted that the 4th instar larvae were most preferred by *D. basalis* followed by pre-pupae, pupae and the third instar larvae. There were a significant difference in host preference by *D. basalis* for the four stages of *C. chinensis* tested ($p<0.001$).

Table 2
Survey of the data on host selection for oviposition on different developmental stages of *Callosobruchus* by *Dinarmus basalis*

Author	Preferred host stage(s) (from most to least accepted)	Other accepted host stage(s) (from most to least accepted)
Alebeek 1991	Last larvae, pre-pupae, pupae	
Boucek 1974	Larvae-pupae	
Chatterji 1954	Mature embryo	
Cheema & Misra 1962	Mature larvae	
Gomez-Alvarez 1980	Larvae-pupae	
Leong & Dickason 1975	Larvae-pupae	
Southgate 1979	Larvae-pre-pupae, pupae	
Verma 1990	Larvae	
This paper	4th instar, pre-pupae, pupae	3rd and 2nd instar

It was observed that selection of host by *D. basalis* is largely accomplished by the antennae and sometimes by the ovipositor. Nell *et al.* (1976) observed the same results in *Encarsia formosa* but they did not mention the factors causing the difference in acceptance of different stages for oviposition equally. They got the impression that the detection of the host size (by drumming and turning on it) and olfactory information (obtained by the antennae during drumming) are important. Hearing (resonance of the host when being drummed upon) may play a role, they suggested. Dhir (1977) observed that *D. vagabundus* deposited eggs within 2-3 minutes on the fully grown bruchid larva whereas 5-7 minutes on the early stage larva.

The present findings suggest that a higher percentage of offspring emerged from the 4th instar larvae followed by pre-pupae and pupae. The parasitoid could easily recogniz these stages and subsequently the time of ovipositor insertion was shorter than that of other stages. Chartterji (1955) reported that host preference of *Anisopteromalus calandrae* in a four-way-choice experiment was *C. analis*> *C. chinensis*> *Sitophilus oryzae*> *Rhyzopertha dominica* and that the parasitoids attacked mature host larvae of these four species. Okamoto, (1972) found parasitism of *C. chinensis* by *A. calandrae* to be greater on third and fourth instars. Host selection was performed while drumming and turning on the host (antennal test) and/or while adopting oviposition posture, moving and standing still (ovipositional test).

It has been suggested that by attacking different host stages the parasitoids partition the resource and interspecific completion is one of the selective forces which has shaped parasitoid complexes (Force 1975; Askew 1975; Price 1975). Some parasitoids attack early host stages, taking advantage of the fact that they were more numerous than older hosts; others, usually good competitors, attack later and were able to eliminate the parasitoids which attacked the early stages. Hence, interspecific competitors

may be one of the selective forces operating on host selection. Encounter probability, handling time and profitability of the hosts in terms of offspring survival, as well as intra-and interspecific competition may all determine host stage selection.

Due to larger size 4th instar larvae and pre-pupae were easily recognize by *D. basalis* with the help of antennae and ovipositor than the other stages. So, it is concluded that *D. basalis* although can propagate on all the developmental stages of the host, it prefers the 4th instar larvae followed by the pre-pupae and pupae.

ACKNOWLEDGEMENTS

The author would like to thank the Ministry of Science and Technology, Government of the People's Republic of Bangladesh, Dhaka for financial support and to thank Director, Institute of Biological Sciences, Rajshahi University, for laboratory facilities.

REFERENCES

Askew, R. R. (1975) The organisation of chalcidoid-dominated parasitoid communities centered upon endophytic hosts. In *Evolutionary Strategies of Parasitic Insects and Mites*. (P. W. Price, ed). Plenum, New York, pp. 130–153.

Ellows, T. S. and M. P. Hassel, (1988) The dynamics of age-structured host-parasitoid interactions. *J. Anim. Ecol.* **57**: 259–268.

Chatterji, S. (1955) Studies on the biology of *Aplastomorpha calandrae* Howard (Insecta: Hymenoptera: Chalcidae) parasitic on some storage pests. *Proc. Zool. Soc.* **8**: 11–23.

Dhir, S. (1977) Further observations on oviposition of *Dinarmus vagabundus* Timb. (Hymenoptera: Pteromalidae). *Curr. Sci.* **46**(1): 18.

Force, D. C. (1975) Succession of r and k strategists in parasitoids. In *Evolutionary Strategies of parasitic and mites* (P. W. Price, ed), Plenum, New York, pp. 112–129.

Heinz, K. M. and M. P. Parrella, (1990) The influence of host size on sex ratios in the parasitoid *Diglyphus begini* (Hymenoptera: Eulophidae). *Ecol. Entomol.* **15**: 391–399.

Islam, W. (1994a) Effect of host age on rate of development of *Dinarmus basalis* (Rond. Hymenoptera: Pteromalidae). *J. Appl.* **118**: 392–398.

Islam, W. (1994b) Discrimination between parasitized and unparasitized hosts, *Callosobruchus chinensis* L. by the parasitoid, *Dinarmus basalis* Rond. Hymenoptera: Pteromalidae). *J. Bio-sci*, **2**: 1–6.

Islam, W., K. N. Ahmed, and M. A. Malek, (1985) Hymenopterous parasites of insect pests of two stored pulses. *Bangladesh J. zool.* **13**: 81–85.

Islam, W. and S. M. H. Kabir, (1985) Biological control potential of *Dinarmus basalis* (Rond.) Hymenoptera: Pteromalidae), a larval-pupal ectoparasitoid of the pulse beetle, *Callosobruchus chinensis* L. *Crop Protection* **14**: 439–443.

King, B. H. (1991) A field study of host size effects on sex ratio of the parasitoid was *Spalangia cameroni*. *Am. Midl. Nat.* **125**: 10–17.

Nell, H. W., L. A. Sevenster-Van Der Lelie, J. Wotes & J. C. Van Lenteren (1976) The parasite-host relationship between *Encarsia formosa* (Hymenoptera: Aphelinidae) and *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). II. Selection of host stages for oviposition and feeding by the parasite. *Z. ang. Ent.* **81**: 372–376.

Okamoto, K. (1972) The synchronization of the life cycles between *Anisopteromalis calandrae* (Howard) II. The relationship between the development of the parasite and the developmental stage of the host. *Japanese J. Ecol.* **22**: 238–244.

Price, P. W. (1975) Reproductive strategies of parasitoids. In *Evolutionary strategies of parasitic insects and mites*. (P. W. Price, ed.), Plenum, New York, pp. 87–111.

Wylie, H. G. (1964) Effect of host age on rate of development of *Nasonia vitripennis* (Walk.) (Hymenoptera: Pteromalidae). *Can. Ent.* **96**: 1023–1027.

Southgate, B. J. (1979) Biology of the Bruchidae. *Ann. Rev. Ent.* **24**: 465–466.

Yoo, C.K; Ryoo, M. I. (1989) Host preference of *Lariophagus distinguendus* (Forester) (Hymenoptera: Pteromalidae) for the instar of rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculiniodae) and sex ratio of the parasitod in relation to the host. Korean *J. Appl. Entomol.* **28**: 28–31.

Entomon 22(2): 101–104 (1997)

Lipase Activity in the Fat Body of *Chrysomyia rufifacies* During Larval Growth and Metamorphosis

J. J. Pol* and V. A. Sawant

Department of Zoology, Shivaji University
Kolhapur, 416004, Maharashtra State, India

Abstract: Changes in lipase activity in the fat body of *Chrysomyia rufifacies* during larval growth and metamorphosis were studied. Low activity during larval growth suggests the accumulation of lipid in the fat body in the form of triacylglycerol. The maximum activity was found in the fat body of prepupa which suggests the mobilization of lipid for utilization during metamorphosis. The lipase activity is maximum at the broad pH range 8.5 to 9.0 indicating that in the fat body extra digestive alkaline lipase is present. This hydrolyzes the triacylglycerol to diacylglycerol and fatty acid.

Keywords: Lipase, Fat body, Blowfly, *Chrysomyia rufifacies*. Metamorphosis.

INTRODUCTION

Employing a histochemical method George and Eapen (1959) detected the presence of a lipase in the fat body. The major lipid component of the insect fat body is long chain fatty acid triglyceride (Fast 1964, Gillby 1965). The fat body is a source of fat supply as energy fuel to the muscle especially for sustained activity as during migratory flight (Domrose and Gilbert 1964, Chino and Gilbert 1964, 1965).

During fat mobilization in *Locusta migratoria* 1,2 diacylglycerol is released from the fat body into the haemolymph. Thus a specific lipase which converts triacylglycerol to 1,2 diacylglycerol should be present in the fat body (Tietz and Weintraub 1978). The level of lipase activity in tissues of third day instar larvae of the blowfly, *Calliphora erythrocephala* has been measured. In fat body, lipase activity was maximal at pH 7 to 8. Lipase activity rose to maximum at rounded-off white puparia (RO) stage. A large amount of triglyceride was found in the fat body (Price 1975). Two lipases have been described in the fat body of *Locusta migratoria* one of which (alkaline lipase) preferentially hydrolyzes monoacylglycerol where as the other (acid lipase) is also strongly active against triacylglycerol and diacylglycerol (Tietz and Weintraub 1978).

The triacylglycerol hydrolyzing capacity of the tissue homogenates has been investigated for midgut, fat body, thoracic musculature and haemolymph of American cockroach *Periplaneta americana*. (Hoffman and Downer 1979).

Received in February, 1993. *Corresponding author

Lipase activity during embryogenesis, larval growth and metamorphosis of *Chrysomyia rufifacies* has been studied (Pol and Sawant 1989, 1990, 1995). There is gradual increase in the lipase activity during larval growth and sudden rise in second day pharate adult stage then decrease in the activity.

But this study was conducted on whole body homogenates rather than tissue homogenates. Therefore in the present work lipase activity of the fat body has been measured and the results are discussed with regard to the changes undergone by the larval growth and metamorphosis.

MATERIALS AND METHODS

Blowflies, *Chrysomyia rufifacies* were reared as described by Munich (1959). The hatching of eggs occurred within 20 hours after oviposition. The larval growth was computed from the mean time of egg hatching (± 1.0 Hr.) to the prepupal stage. The larval stage lasted for four days. The prepupation and pupation lasted for one and five days respectively. Studies were carried out at an interval of 24 hours in each case of prepupation and pupation.

For the study of lipids and lipase activity the following stages were selected : Third day larva (L_3), fourth day larva (L_4), Prepupa (PP), fourth day pharate adult (P_4), fifth day pharate adult (P_5) and first day adult (A_1). No tissues were observed in first, second and third day pharate adults due to histolysis.

All the solvents were of reagent grade and were obtained from E. Merck and Co. Rahway, N. J., U. S. A. and B. D. H., England. Unless otherwise indicated solvents were redistilled in the laboratory under anhydrous condition before use. Diphenyl Carbazide was purchased from E. Merck, Dermstat, Germany. Diphenyl carbazone was of Veb. Jenapharm Laborchemie, Apolda Germany. Triolein, Diolein, Monolein, Stearic Acid, BSA were obtained from Sigma Chemical Company, U. S. A.

Fat bodies from the various life stages of *Chrysomyia rufifacies* were isolated under ice cold Ringer's solution. The fat bodies were cleaned with cold double distilled water, weighed and homogenized in cold double distilled water using a ground glass pestle and morter. The homogenates were diluted with the cold double distilled water so as to get 1% (wt/vol) concentration. Such homogenates were used for the biochemical assay of the lipolytic activity (EC 3.1.1.3.) as described by Patil *et al* (1983). Protein was determined by the method of Lowry *et al* (1951). Triglycerides from olive oil were purified and the emulsion of triglycerides were prepared according to the method adapted by Patil *et al* (1983).

RESULTS AND DISCUSSION

Changes in lipase activity in fat body of *Chrysomyia rufifacies* during larval growth and metamorphosis are shown in Fig. 1. There was an increase in the lipase activity in the fat body of larvae from third to fourth day larvae. It increased ten times in Prepupae as compared to third day larvae. It decreased in fourth, fifth day pharate adults and freshly emerged adults. The maximum lipase activity was observed in fat body of prepupae. The lipolytic activity was maximal at the broad pH range 8.5 to 9.0. The hydrolysis products on thin layer chromatography plates disclosed a predominance to diacylglycerol and decrease in the concentration of triacylglycerol.

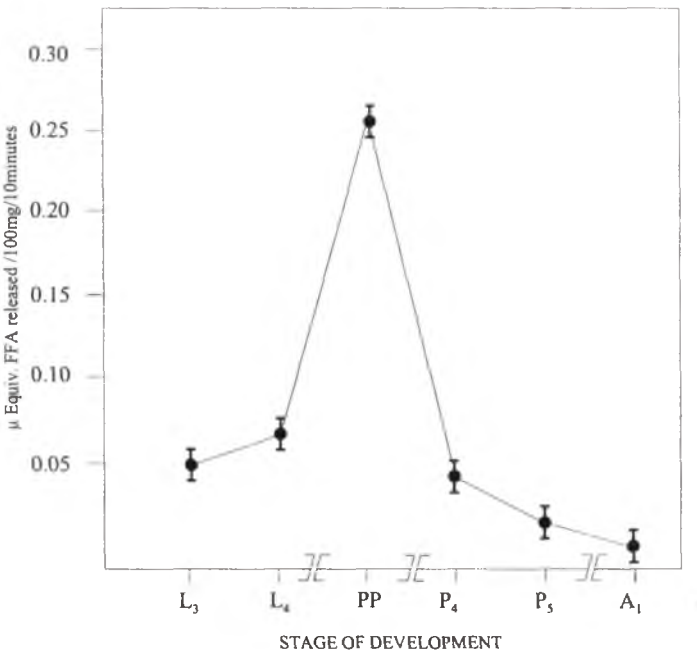


Fig. 1. Lipase activity in fat body of *Chrysomyia rufifacies* during growth and metamorphosis.

The fat body contains triglycerol which may be released into the haemolymph for distribution to other tissues in the form of diacylglycerol by the action of triacylglycerol lipase. (Hoffman and Downer 1979).

The pH optimum range 8.5 to 9.0 indicates the presence of alkaline lipase in the fat body. The results reported herein suggest that extra digestive alkaline lipase exist in the fat body of *Chrysomyia rufifacies* and due to this lipase diglycerol may be released from the fat body and served as important intermediate in the breakdown of triacylglycerol.

Most insect accumulate large quantities of lipid during larval period. The lipid is stored in the fat body in the form of triglycerides (Price 1975). The lipid store is then utilized to provide energy for the metamorphosis (Rao and Agarwal 1970, 1971). In *Chrysomyia rufifacies* triglycerides accumulate gradually and attains high concentration in Prepupae (Pol and Sawant 1990).

The lower level of lipase activity in larval fat body suggests the decreased rate of hydrolysis of lipid and synthesis, deposition of lipid. The high level of lipase activity in the fat body of prepupa suggests the possible mobilization of lipid for utilization during metamorphosis. Low lipase activity in third day and fourth day pharate adult indicates the histogenesis. Price (1975) suggested the possibility that the lipase is stored in the lysosomes and that not until metamorphosis when fat body undergoes lysis, do these fuse with the lipid droplets so bringing the enzyme into contact with its substrate. The results obtained in the present work support the possibility suggested by Price (1975).

ACKNOWLEDGEMENT

The author J. J. Pol is grateful to U.G.C. for the award of Teacher Fellowship.

REFERENCES

Chino, H. and L. I. Gilbert (1964). Diglyceride release from insect fat body : A possible means of lipid transport. *Science* **143**: 359–361.

Chino, H. and L. I. Gilbert (1965). Lipid release and transport in insects. *Biochem biophys Acta* **98**: 94–110.

Domroes, K. A. and L. I. Gilbert (1964). The role of lipid in adult development and flight muscle metabolism in *Hyalophora cecropia*. J. Exp. Biol. **41**: 573–590.

Fast P. G. (1964). Insect lipids : A review Mem. Ent Soc. Canada. **37**: 1–50.

Folch, J., M. Lees and G. H. Sloane Stanley (1957). A simple method for the isolation and purification of total lipid animal tissues *J. Biol. Chem.* **226**: 497–509.

George, J. C. and J. Eapen (1959). Histochemical demonstration of lipase and alkaline phospatase activity in the fat body of the desert locust. *Nature* **183**: 268.

Gilby, A. R. (1965). Lipid and their metabolism in insects. *Annu Rev. Ent.* **10**: 141–160.

Hoffman, A. G. D. and R. G. H. Downer (1979). End product specificity of triacylglycerol lipases from intestine, fat body, muscle, haemolymph of American Cockroach. *Periplenta americana : lipids*, **14**: 893–399.

Lowry, O. H. Rosebrough, N. J. Farr, A. L. and Randal, R. J. (1951) *J. Biol. Chem.*, **193**: 265.

Munich, D. E. (1959). In culture Methods of Invertebrate animals (Ed. by Lutz, F. E., Weich, P., Gattsoff, P. and Needham, J.) pp 414–417, Dover, New York.

Patil, S. S., C. K. Bhandari and V. A. Sawant (1983). Studies on triacylglycerol ester hydrolase from bat adipose tissue. *J. Biasci*, **5**(1): 35–42.

Price, G. M. (1975). Lipase activity in third instar larvae of the blowfly, *Calliphora enythrocephala Insect Biochem.* Vol. **5**: 53–60.

Pol, J. J. and V. A. Sawant (1989). Studies on Lypolytic activity profile of eggs of *Chrysomyia rufifacies*, during embryogenesis *J. Adv. Zool.* **10**(1): 42–49.

Pol, J. J. and V. A. Sawant (1990). Studies on Lypolytic activity profile of larva of *Chrysomyia rufifacies*. during larval growth. Ad. Bios. Vol. **9(II)**: 61–68.

Pol, J. J. and V. A. Sawant (1995). Lypolytic activity during metamorphosis of *Chrysomyia rufifaciesr*, ENTOMON, Vol. **20**(2): 51–53.

Rao, K. D. P. and H. C. Agarwal, (1970). Lipids of *Trogoderma granarium* Evert II, Lipids and Glycogen content during development *Indian J. Ent* **12**: 118–121.

Rao, K. D. P. and H. C. Agarwal, (1971). Lipids of *Trogoderma* III. Phospholipids and fatty acid composition during development with note on fatty acid biosynthesis, *Comp. Biochem. Physiol*, **39B**: 183–194.

Tietz, A. and Weintraub, H (1978). Hydrolysis of glycerides by lipases of the fat body of the locust. *Locusta Migratoria. Insect Biochem* **B**: 11–16.

Wagner, H. L. Hormer and P. Wolff (1961). ILC of phospholipids and glycolipids, *Biochem J.* **334**: 175.

Entomon 22(2): 105–110 (1997)

Population Fluctuation of Rice Tarsonemid Mite, *Steneotarsonemus spinki* Smiley (Acari: Tarsonemidae) in the Rice Ecosystem

S. K. Ghosh,[1]* Jagadiswari Rao[2] and Anand Prakash[2]

[1]*Div. of Entomology and Nematology, Indian Institute of Horticultural Research*
Hessaraghatta Lake Post, Bangalore 89, India

[2]*Grain Entomology Laboratory, Central Rice Research Institute*
Cuttack 753006, Orissa, India

Abstract: Rice tarsonemid mite, *Steneotarsonemus spinki*, was found to infest rice plant throughout the year. Population of *S. spinki* fluctuated between a high peak during November (586.70–633.30 mites/tiller) and low peak during February (44.30–52.70 mites/tiller). Population was highest at the booting stage and declined afterwards with the maturity of the plant. Correlation analysis revealed that less rainfall and more sunshine had favoured mite multiplication.

Keywords: Tarsonemid, *Steneotarsonemus*, Population fluctuation, Rice.

INTRODUCTION

Rice Tarsonemid mites *viz.*, *Steneotarsonemus spinki* Smiley and *Tarsonemus* sp. are known to deteriorate rice grain quality and also cause panicle sterility in Madagascar (Gutierrez, 1967) Taiwan (Lo and Ho, 1977) Phillipines (Hshieh, 1977) and India (Rao and Das, 1977; Rao and Prakash, 1992). Rice is the only food plant of *S. spinki* and population was found to be abundant in between the heading and milky stages (Chen, *et al.*, 1979). Japonica varieties are more susceptible to this mite and can damage up to 20% of the production (Ou, *et al.*, 1977). However, Indica varieties received very less infestation (Ou, 1976, Lee, 1980). Besides occurrence, no further information is available for *S. spinki* on Indica rice varieties. Present investigation highlights the establishment of *S. spinki* population in relation to the growth of rice plant and the role of abiotic factors on its fluctuation.

MATERIALS AND METHODS

Under net house condition

Rice plants were grown on earthern pots (14″ dia.) throughout the year under net house conditions by transplanting the seedling of variety Ratna at 15 days interval. Inocula-

Received in May, 1997. *Corresponding author

tion of mites was done in 30 day's old seedling by putting the small (2.5 cm) cutpieces of infested rice stem, after proper observations of its populations under stereoscopic binocular microscope at the rate of 30 per tiller. The seedlings were allowed to grow upto mature stages and samples were collected every month throughout the year for the period of 1993 and 1994. Nymph and adult population per tiller were recorded by using counter disc under stereoscopic binocular microscope.

Under field conditions

Since the incidences of *S. spinki* was found to be more during kharif seasons than rabi seasons, observations were confined to only during kharif of both 1993 and 1994. Samples of variety Ratna were collected from the untreated experimental plots of CRRI field at 15 day intervals, starting from 15 days old seedling to harvesting of the crop. Collected samples were brought to the laboratory and counted for the nymph and adult mites under stereoscopic binocular microscope.

The weather data (minimum temperature, maximum temperature, relative humidity, rainfall and sunshine) relevant to the period were also recorded regularly and correlated with mites population by simple and multiple regression analysis.

RESULTS

Under net house conditions

The rice tarsonemid mite, *S. spinki* was found to infest rice plant throughout the year with higher population during kharif 1993 and 1994 (Table 1). The highest population was recorded during the month of November, (586.70 and 633.30 mites/tiller) and the lowest in the month of February, 1993 and 1994 (44.30 and 52.70 mite/tiller). When nymphal, adult and total population of *S. spinki* were analysed by using simple correlation, only total population showed significant negative correlation with rainfall (R=–0.616) and positive relationship with maximum temperature and relative humidity while negative relationship with minimum temperature. When population of *S. spinki* was analysed with different weather factors by using multiple correlation, rainfall combined with maximum temperature was found to be a significant component contributing to coefficient of determination value (R^2) of 18.07% while all the abiotic factors combindly contributed to total R^2 value of 18.73% (Table 2).

Under field condition

The population of *S. spinki* was found to increase gradually with the growth of rice plant (Table 3). Lowest population was recorded in 30 day's old transplanted plant (3.30 - 5.20 mites/plant) and was found to increase through different growth stages of the rice plant and reach the maximum at booting stage (293.60 - 310.00 mites/tiller). After booting stage population was found to decline with the maturity of the plant. Among different abiotic factors rainfall showed highly significant negative correlation (R=–0.613) and sunshine have a positive and highly significant correlation (R=0.969) with mites population.

When relationship was analysed by using multiple correlation relative humidity, rainfall and sunshine hours were found to be significant components contributing to a

Table 1
Population of *S. spinki* in relation to the weather factors under net house condition at CRRI during 1993 and 1994

Month	Temperature (°C)		R.H (%)	Rainfall (mm)	Mite Population/Tiller*		
	Min	Max			Nymph	Adult	Total
Jan'93	12.7	26.5	92	17.2	34.4	16.9	51.3
Feb	12.5	29.1	93	120.9	24.9	19.9	44.3
Mar	20.7	37.7	94	0	39.1	13.5	52.6
Apr	23.3	36.6	86	8.8	66.8	68.9	130.2
May	25.8	35.2	87	142.8	85.9	94.4	180.3
Jun	25.9	24	91	161.5	117.2	149	266.2
Jul	25.2	31.3	92	481.5	82.5	110.3	192.8
Aug	26.4	30.5	92	267.9	96.5	221.6	218.1
Sept	25.3	31.4	93	1130.4	70.4	82.1	152.5
Oct	23.9	31.3	91	78.8	112.3	173.1	285.4
Nov	19.7	29.2	90	1	244.1	342.6	586.7
Dec	12.6	27.9	93	0	85.5	126.8	212.3
Jan'94	14.8	28.4	93	0	39.3	32.8	72.1
Feb	18.3	29.1	95	18.4	32.7	20	50.7
Mar	22.5	34.6	93	0	36.5	27.74	64.24
Apr	24.2	37.7	89	75.4	65.18	58.1	123.28
May	26.6	37.7	89	54.6	92.3	106.23	198.53
Jun	26.2	32.6	93	171.9	127.3	152.81	280.11
Jul	25.6	31.5	93	236.3	88.7	126.63	215.53
Aug	25.5	31.7	93	409.8	76.5	109	185.5
Sept	25.5	31.3	93	188.8	108.2	130.2	238.4
Oct	24.1	31.3	93	98.3	164.25	230.75	395
Nov	19.4	28.7	93	5.2	265.3	368	633.3
Dec	13.6	13.6	91	0	113.5	187.5	336.88

* Mean of ten observations

Table 2
Multiple correlation analysis of mite population with different weather factors under net house conditions

$Y = 2020.94 + 9.378X_1 - 20.926X_2 - 14.744X_3 - 0.201X_4$ with r^2 value 18.73%
$Y = 2020.94 + 9.378X_1 - 20.926X_2 - 14.744X_3$ with r^2 value of 16.75%
$Y = 2155.39 - 15.084X_2 - 15.925X_3 - 0.040X_4$ with r^2 value of 12.00%
$Y = 2230.62 - 15.26X_2 - 16.75X_3$ with r^2 value of 11.67%
$Y = 578.32 - 11.26X_2 - 0.061X_4$ with r^2 value of 18.07%.

Y = Total population; X_1 = Minimum temperature; X_2 = Maximum temperature; X_3 = Relative humidity; X_4 = Rainfall

Table 3
Population of *S. spinki* in relation to the weather and growth of the rice plant under field condition during kharif 1993 and 1994 at CRRI

Month	Fort night	Temperature (°C) Max	Min	R.H. (%)	Rainfall (mm)	Sunshine	Growth Stages of rice	Total Mites* pop (Adult & Nympth)
June'93	I						S	
	II	30.8	25.6	94	438.8	3.9	S	
July	I	31.8	26	92	270.9	3.5	SL	0.00/plant
	II	32.9	25.9	89	324.3	6.4	P	3.35/plant
August	I	29.8	25.2	95	355.6	3.7	ET	16.45/tiller
	II	31.5	26	91	501.1	4.5	AT	35.50/tiller
September	I	30.2	25	95	124.3	3.7	MT	61.20/tiller
	II	31.1	25.3	94	222.8	4.5	PI	183.05/tiller
October	I	31.8	25.5	93	64	6.6	B	293.60/tiller
	II	31.5	23.3	91	76.8	8.2	M	266.30/tiller
November	I	29.2	19.7	90	1	9	H	148.70/tiller
June'94	I						S	
	II	30.5	25.4	94	171.9	1.7	S	
July	I	30.7	25.6	92	114.1	4.1	SL	0.00/plant
	II	32.6	25.6	92	336.3	4.1	P	5.20/plant
August	I	31.3	25.7	92	109.1	5.4	ET	22.30/tiller
	II	29.8	25.4	94	409.9	3.6	AT	42.50/tiller
September	I	30.9	25.6	93	81.5	4.4	MT	95.20/tiller
	II	32.4	25.5	93	188.8	7.3	PI	202.30/tiller
October	I	31.7	24.6	92	54.3	6.8	B	340.00/tiller
	II	30.9	23.5	93	98.3	7.8	M	246.10/tiller
November	I	27.2	17.7	93	0	8.8	H	195.00/tiller

S-Seed; SL-15 day's old seedling; P-30 day's seedling; ET-Early tillering, AT- Active tillering; MT-Mature tillering; PI-Panicle initiation; B-Booting; M-Milky; H-Harvesting stage.

* Mean of ten observations

total coefficient of determination value (R^2) of 77.71%. Sunshine with rainfall contributed R^2 value of 67.02% while all other abiotic factors combindly contributed R^2 value of 87.57% (Table 4).

DISCUSSION

Under net house conditions mites population remained throughout the year in the potted plants but with two peaks, one in June and another in November. During the period of high rainfall, the mite population had declined. This might be due to the fact that the population could have washed off from the plant. Under field conditions, mite

Table 4
Multiple correlation analysis of mite population with different weather factors under field conditions

$Y = -6584.67 + 29.1164X_1 + 8.621736X_2 + 57.88135X_3 - 0.24729X_4 + 45.998X_5$	with r^2 value of 87.57%
$Y = -3180.10 + 71.7332X_1 - 52.7281X_2 + 25.5228X_3$	with r^2 value of 44.36%
$Y = -358.41 + 51.931X_1 - 45.978X_2$	with r^2 value of 37.45%
$Y = -2765.94 + 27.935X_3 - 0.081X_4 + 50.316X_5$	with r^2 value of 77.71%
$Y = -95.1937 - 0.0748X_4 + 40.51393X_3$	with r^2 value of 67.02

Y = Total population; X_2 = Minimum temperature; X_2 = Maximum temperature; X_3 = Relative humidity; X_4 = Rainfall; X_4 = Sunshine hours

population was recorded in relation to the growth of rice plant, where, it was found to be initiated from early tillering stage and reached it's peak at booting stage and then declined afterwards. This might be due to the accumulation of high nutrients in the leaf sheath during booting stage which afterwards translocated to the grain for it's development. Chen *et al.*, (1979) also reported that *S. spinki* attained its peak population in paddy fields from heading to milky grain stage.

After reviewing simple and multiple correlation between abiotic factors with mite population it is evident that the most favourable combination for multiplication of this mite is less rainfall and more sunshine. The present study is in accordance with the earlier observations (Fang, 1980) that low rainfall and high humidity influenced high incidences of *S. spinki* and temperature was found to show negative correlation.

ACKNOWLEDGMENTS

The authors are grateful to the Director, CRRI Cuttack for providing necessary research facilities and ICAR for funding the scheme under which the investigation has been carried out.

REFERENCES

Chen, C. N., C. C. Cheng and K. C. Hasio (1979). Bionomics of *Steneotarsonemus spinki* Smiley attacking rice plants in Taiwan. *Recent Adv. Acarol.* **1**: 111–117.

Feng, H. C. (1980). Studies on the occurrence of rice tarsonemid mite *Steneotarsonemus spinki* Smiley in relation to meteorological factors and its control. *Res. Bull. Taiwan.* DAIS. **14**: 39–49.

Gutierrez, J. (1967). *Steneotarsonemus madecassus* n.sp. agent l'ure information des paniele de je sizea Madagascar (Acarina; Tarsonemidae). *Bul. Ent. Soc. France.* **72**: 323–337.

Hshieh, K. (1977). Occurrence of the rice tarsonemid mite at IRRI. *Intn. Rice. Res. Newsl.* **2**(5): 17.

Lee, S. C. (1980). Screening of varietal resistance to sterility of rice caused by tarsonemid mites. *Plant Prot. Bull. Taiwan.* **22**(1): 91–100.

Lo, Kan-Chen and Ho, Chyi-Chen. (1977). Preliminary studies on rice tarsonemid mite, *Steneotarsonemus spinki* (Acarina: Tarsonemidae). *National Science Council* (Monthly) **5**(4): 274–284.

Ou, Y. T. (1976). Occurrence of a mite in Taiwan district. *Intn. Rice. Res. Newsl.* **1**(2): 15.

Ou, Y. T. H. C. Fang and Y. H. Tsang, (1977). Studies on *Steneotarsonemus madecassus* Gutierrez on rice. *Plant. Prot. Bull. Taiwan.* **19**(1): 21–29.

Rao, Y. S. and P. K. Das (1977). A new mite pest of rice in India. *Intn. Rice. Res. Newsl.* **2**(1): 8.

Rao, J. and A. Prakash (1992). Infestation of rice tarsonemid mite *Steneotarsonemus spinki* Smiley in rice in Orissa. *J. appl. Zool. Res.* 3(1): 103.

Entomon 22(2): 111–117 (1997)

A Revision of the Idiocerine Leafhopper Genus *Amritodus* (Hemiptera: Cicadellidae) Breeding on Mango

C. A. Viraktamath*

Department of Entomology, University of Agricultural Sciences GKVK, Bangalore 560065, India

Abstract: The genus *Amritodus* is redefined. The included species namely, *Amritodus atkinsoni* (Lethierry), *A. brevistylus* Viraktamath and *A. saeedi* Ahmed *et al.* are redescribed and illustrated along with distribution records. *Amritodus brevis* sp. nov. from Mizoram (Silchar) breeding on mango is also described and illustrated. A key to species of *Amritodus* is also included. *Amritodus pistacious* Huang and Maldonado Capriles (from Taiwan) is removed from the genus.

Keywords: *Amritodus*, new species, mango, Cicadellidae, leafhoppers.

INTRODUCTION

The genus *Amritodus* was described by Anufriev (1970) with *Idiocerus atkinsoni* (Lethierry) as its type species. Viraktamath (1976) described two new species, *Amritodus brevistylus* and *A. mudigerensis* from South India. Later, Viraktamath and Murphy (1980) transferred *A. mudigerensis* to the genus *Busoniomimus* Maldonado Capriles. Ahmed *et al.* (1980) described a new species, *Amritodus saeedi* breeding on mango from Karachi (Pakistan), thus bringing the species of *Amritodus* from the Indian subcontinent to three. Huang and Maldonado Capriles (1992) added *Amritodus pistacious* breeding on *Pistacia chinensis* (Anacardiaceae) from Taiwan, thus extending the distribution of the genus outside the subcontinent.

The species of *Amritodus* are known to be serious pests of mango along with the species of *Idioscopus* Baker (Viraktamath, 1989). All the species of *Amritodus* except *A. pistacious* use mango, *Mangifera indica* as a breeding host. During non-breeding season they are found on the trunk of mango tree (Wagle, 1934).

In this paper a new species of *Amritodus* from northeast India is described along with redescription of the known species from the Indian subcontinent. The types of the new species are deposited in the University of Agricultural Sciences, Bangalore (UAS), The Natural History Museum, London (NMH) and the U. S. National Museum of Natural History (USNM), Washington D. C.

Received in November, 1996.

*Corresponding author

Genus *Amritodus* Anufriev

Amritodus Anufriev, 1970: 376. Type species, *Idiocerus atkinsoni* Lethierry, by original designation.

Yellowish brown to brown, with a pair of black spots on upper part of face, anterior margin of pronotum; basal triangles of scutellum brownish to black. Forewing venation prominent. Ovipositor black.

Head wider than pronotum. Upper part of face and vertex finely transversely rugulose. Vertex short, shorter medially than next to eyes. Face including eyes wider than long, ocelli closer to eyes than to each other. Lorum slightly raised from general surface. Clypellus rather abruptly widened at apical 0.25 distance where it is depressed. Pronotum shorter than scutellum, shagreened. Forewing with both outer and inner subapical cells open behind, with four apical cells. Both tergal and sternal apodemes of third abdominal segment well developed.Hind tibial spinulation R_1 19±1, R_2 6, R_3±1. Hind basitarsus with four platellae.

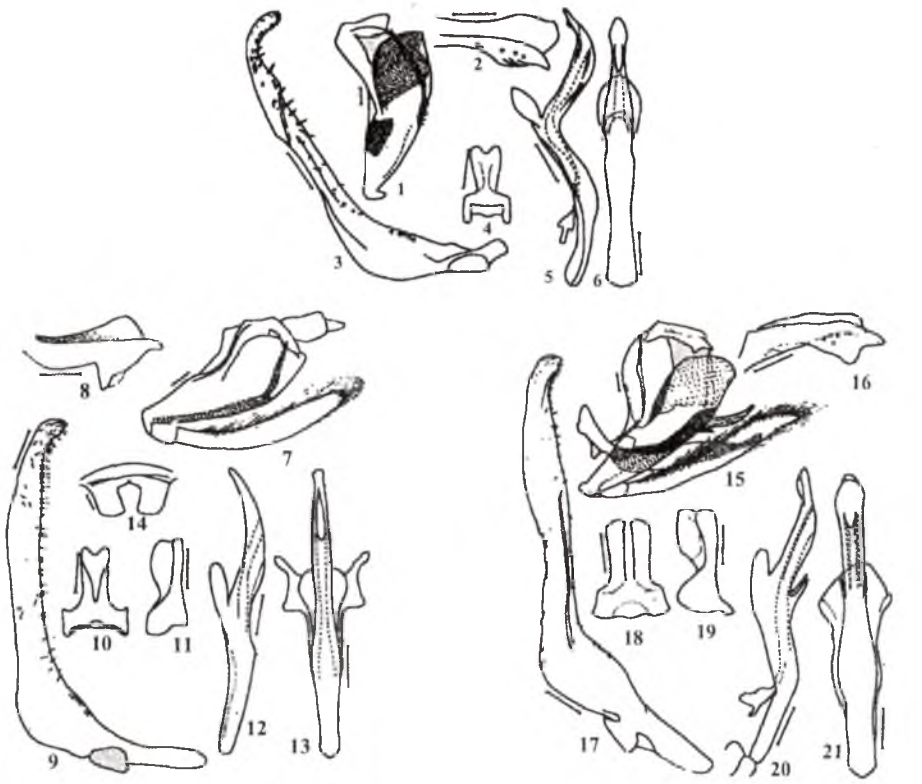
Male pygofer longer than height with prominent anterior apodemes. Anal collar well developed, sclerotized with a short caudal process. Pygofer with a basal fracture, each lobe with a transverse unpigmented area, ventral margin infolded in anterior 0.5 to 0.75 distance and produced into a dorso-caudally directed spine-like appendage. Subgenital plate with a basal short segment, leaf-like, unpigmented with either long or short hair-like setae. Style elongate, with a short anterior lobe, caudal process long, with either short stout or fine setae, apex variously curved. Connective T-shaped, with a prominent dorsal keel, stem of T rather bilobed. Preatrium of aedeagus elongate, as long as or longer than often slightly curved shaft, dorsal apodeme plate-like. Gonopore subapical.

Female seventh sternum with rather concave hind margin. Ovipositor exceeding pygofers. Second pair of valvulae with denticles restricted to caudal 0.25 length.

The genus is related to *Idioscopus* but differs in lacking long processes to the shaft and possessing prominent ventrally directed preatrium.

A. pistacious which was provisionally placed in the genus by Huang and Maldonado Capriles (1992) differs from the typical species of *Amritodus* in having outer subapical cell closed behind, non-T-shaped connective, differently shaped aedeagus and style. In all probability it may belong to the genus *Philippocerus* Maldonado Capriles and hence it is removed from *Amritodus*.

1. Males 2
2. Females 5
3. Subgenital plates short, devoid of long hair-like setae (Fig. 35); aedeagal shaft with subapical tooth on either side (Fig. 39) (India: Mizoram) .*A. brevis* sp. nov.
   - Subgenital plates longer, at least as long as pygofer (Fig. 7); aedeagal shaft either without processes or with basal pair of spine-like processes (Figs. 5, 12, 20) .. 3
4. Style apex strongly curved caudally, with stout, short setae (Fig. 3) .*A. atkinsoni* (Lethierry)
   - Style apex not strongly curved caudally, with hair-like setae or with stiff slender setae (Figs. 9, 17) 4
5. Aedeagal shaft without processes ..... *A. saeedi* Ahmed *et al.*
   - Aedeagal shaft with basal pair of spine-like processes (Fig. 20) ..*A. brevistylus* Viraktamath



Figs. 1–6. *Amritodus atkinsoni* (Lethierry): 1. Male pygofer; 2. Anal collar process; 3. Style; 4. Connective; 5. Aedeagus, lateral view; 6. Aedeagus, caudal view.
Figs. 7–14. *Amritodus saeedi* Ahmed, Naheed and Ahmed: 7. Male pygofer; 8. Anal collar process; 9. Style; 10. Connective; 11. Same, lateral view; 12. Aedeagus, lateral view; 13. Same, caudal view; 14. Sternal apodemes.
Figs. 15–21. *Amritodus brevistylus* Viraktamath. 15. Male genitalia; 16. Anal collar process; 17. Style; 18. Connective; 19. Same lateral view; 20. Aedeagus, lateral view; 21. Aedeagus, caudal view.

6. Hind margin of seventh sternum with a median and a lateral shallow concavity (Fig. 32) ..... *A. brevis* sp. nov.
   - Hind margin of seventh sternum deeply concave (Figs. 26–28) 6
7. Median region of hind margin of seventh sternum straight (Fig. 26) ... *A. saeedi* Ahmed *et al.*
   - Median region of hind margin of seventh sternum concave (Figs. 27, 28) 7
8. Lateral margin of seventh sternum (Fig 27) ..... *A. brevistylus* Viraktamath
   - Lateral margin of seventh sternum abruptly incurved in basal half then straight (Fig. 28) ..... *A. atkinsoni* (Lethierry)

***Amritodus atkinsoni* (Lethierry)**

(Figs. 1–6, 28)

Idiocerus atkinsoni (Lethierry) 1889: 252. Syntype male, India: Calcutta (National Museum of Natural History, Paris, examined)

Idiocerus quinquepunctatus Melichar, 1903: 146. Sri Lanka (not examined)
Amritodus atkinsoni: Anufriev, 1970: 376.
Distant (1908) has given good colour description of this species.

Male genitalia : Anal collar process with bifid caudal apex, more caudal lobe rounded, rather less sclerotized, anterior lobe with crenulate lower margin and distally pointed. Ventral process of pygofer exceeding pygofer lobe. Subgenital plates as long as pygofer, with long hair-like setae. Caudal apex of style curved laterally, with short, stout setae. Aedeagal shaft without processes, curved dorsally, rather abruptly near apex, preatrium 1.6 times as long as shaft.

Female genitalia : Hind margin of seventh sternum deeply concave, lateral lobes slightly pointed, lateral margin abruptly concavely excavated at basal half, then straight.

Measurements : Male 4.7 mm long, 1.8 mm wide across eyes. Female 4.8–4.9 mm long, 1.8 mm wide across eyes.

Material examined : Syntype male, INDIA: West Bengal: Calcutta (NMNH). Other material: Several males and females collected on mango from Uttar Pradesh: Dehra Dun, Punjab: Ludhiana, Gujarat: Anand, Junagadh, Navsari, Maharashtra: Dapoli, Karnataka: Raichur, Dharwad, Gadag (UAS).

Remarks : This species can be recognised by the style which has laterally curved apex, with short stout spines and rather strongly curved apex of aedeagal shaft. Externally it resembles *A. brevistylus* closely and can be easily misidentified without recourse to the study of male genitalia.

Amritodus saeedi Ahmed, Naheed and Ahmed

(Figs. 7–13, 22–26)

Amritodus saeedi Ahmed, Naheed and Ahmed, 1980: 221. Holotype male, PAKISTAN: Karachi (not examined).

Colouration similar to that in *A. brevis* sp. nov. (see below)

Male genitalia : Anal collar process with an anterior and a caudal bluntly produced projections. Ventral process of pygofer exceeding pygofer lobe. Subgenital plate slightly broadened apically, longer than pygofer, with long hair-like setae. Style with very short laterally curved apex, setae slender, short. Aedeagal shaft narrowed distally, uniformly curved dorsally, preatrium as long as shaft.

Female genitalia : Hind margin of seventh sternum straight in the middle with well rounded lateral lobes.

Measurements : Male 5.1 (4.9–5.2) mm long, 1.9 mm wide across eyes. Female 5.6 (5.2–5.9) mm long, 2.0 mm wide across eyes.

Material examined : INDIA: Karnataka: 1 male, 1 female, Jog Falls, 534 m, 18.xi.1976, C. A. Viraktamath, 1 female, same data but collected on 2.iv.1978 by C. S. Wesley; 1 male, 2 females, Mangalore, 16.v.1986, C. A. Viraktamath, 1 female, same data but collected on 4-6.iv.1980 (UAS).

Remarks : *A. saeedi* is closely related to both *A. atkinsoni* and *A. brevistylus* but lacks the median fuscous stripe on pronotum and scutellum. It shares the character of simple aedeagus with *A. atkinsoni* but has much shorter preatrium and shares the shorter style with that of *A. brevistylus* but lacks the basal processes to the aedeagal shaft. This appears a distinct species distributed along the coastal region in the Indian subcontinent. It occurs along with *A. brevistylus* in south India (in Mangalore and Jog Falls).

Amritodus brevistylus Viraktamath

(Figs. 15–21, 27)

Amritodus brevistylus Viraktamath, 1976: 234. Holotype male, India: Bangalore (Zoological Survey of India, Calcutta, examined).

Colouration similar to that of *A. atkinsoni* but paler. Basal triangles on scutellum brown rather than black.

Male genitalia : Anal collar appendage with caudal and anterior projections. Pygofer as in *A. atkinsoni*. Style with caudal apex truncate, with slender setae. Aedeagal shaft rather straight with a basal pair of short spines on ventral surface, preatrium 1.5 times as long as shaft.

Female genitalia : Seventh sternum with concavely curved hind margin, lateral margins uniformly concavely curved, lateral lobes rather pointed.

Measurements : Male 5.0 (4.9–5.0) mm long, 1.8 mm wide across eyes. Female 5.2 (4.9–5.4) mm long, 2.0 mm wide across eyes.

Material examined : Holotype male, INDIA: Mysore St. Bangalore Viraktamath, C. A. (Zoological Survey of India, Calcutta).

Other material : several males and females from Karnataka: Bangalore, Dharwad, Raichur, Jog Falls, Mangalore, Gadag, Tamil Nadu: Cinchona (UAS).

Remarks : This species occurs in the southern parts of India. It co-occurs along with *A. atkinsoni* in Dharwad and Raichur, however, no intermediate forms (hybrids?) are found so far.

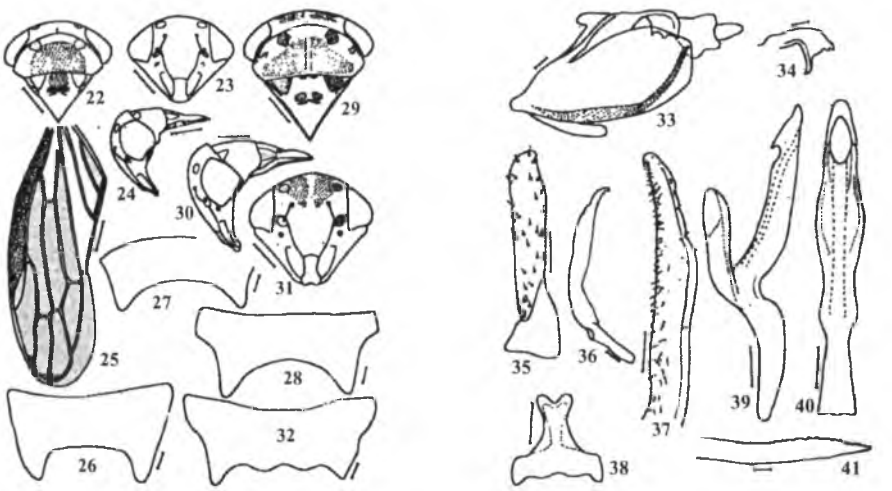
Amritodus brevis sp. nov.

(Figs. 32–41)

Colouration similar to that in *A. atkinsoni* but the black markings more pronounced and brown markings absent. A median line on upper part of face, vertex and pronotum, lateral margins of scutellum (except in apical half) yellow.

Anterior half of scutellum roughly sculptured, posterior half wrinkled.

Male genitalia : Pygofer deeper than in other species of *Amritodus*, ventral process almost half as long as basal fold not exceeding pygofer. Anal collar process well sclerotized with an anterior longer and a caudal shorter, stouter bifid projection. Subgenital plate half as long as pygofer, devoid of long hair-like setae, but with short hair-like setae. Style slender, narrowed in caudal 0.25 to a tight hook, with fine hair-like setae. Aedeagal shaft straight, with a pair of subapical ventrally directed short projections, preatrium shorter than aedeagal shaft.



Figs. 22–32. Species of *Amritodus*. 22–26. *Amritodus saeedi* Ahmed *et al.* 22. Head and thorax; 23. Face; 24. Same, profile; 25. Forewing; 26. Female seventh sternum. 27. *Amritodus brevistylus* Viraktamath, female seventh sternum. 28. *Amritodus atkinsoni* (Lethierry), female seventh sternum. 29–32. *Amritodus brevis* sp. non. 29. Head and thorax; 30. Same, profile; 31. Face; 32. Female seventh sternum.

Female genitalia : Seventh sternum with shallow median and a lateral concavity on hind margin.

Measurements : Male 5.5 and 6.0 mm long, 2.0 and 2.1 mm wide across eyes. Females 6.0 (5.8–6.3) mm long, 2.1 (2.1–2.2) mm wide across eyes.

Material examined : Holotype male, INDIA: Mizoram: Silchar, Gunghur, 18.xi.1981, C. S. Wesley Coll. (UAS). Paratypes: 1 male and 4 females data as in holotype (NMH, UAS, USNM).

Remarks : This is the largest of the species of *Amritodus*. It can be differentiated from other species of *Amritodus* by its short subgenital plates, shorter preatrium and peculiar anal collar processes in addition to the differently shaped hind margin of female seventh sternum.

ACKNOWLEDGEMENT

I am indebted to Dr. H. Synave, National Museum of Natural History, Paris for loaning the type series of Idiocerinae described by Mr. Lethierry from India.

REFERENCES

Ahmed, S. S., R. Naheed and M. Ahmed, 1980. Three new species of idiocerine leafhoppers. *Proc. 1st Pakistan Congr Zool., B* 1980, 221–225.

Anufriev, G. A. 1970. Description of a new genus *Amritodus* for *Idiocerus atkinsoni* Leth. from India (Hemiptera: Cicadellidae) *J. nat. Hist.*, London 4 375–376.

Distant, W. L. 1908. Rhynchota-Homoptera vol. 4. In: Bingham, C. T. (ed.) *The fauna of British India including Ceylon and Burma*, 521 pp. Taylor and Francis.

Huang, K. W. and Maldonado Capriles, J. 1992. Idiocerinae of Taiwan (Homoptera: Cicadellidae). *J. Taiwan Mus.* **45** (1): 1–14.

Lethierry, L. F. 1889. Definitions of three new Homoptera. *J. Asiatic Soc. Bengal.* **58**: 252–253.

Melichar, L. 1903. *Homoptren-Fauna von Ceylon.* 248 pp.

Viraktamath, C. A. 1976. Four new species of idiocerine leafhoppers from India with a note on male *Balocha astuta* (Melichar) (Homoptera: Cicadellidae: Idiocerinae). *Mysore J. agric. Sci.* **10**: 234–244.

Viraktamath, C. A. 1989. Auchenorrhyncha (Homoptera) associated with mango, *Mangifera indica* L. *Trop. Pest Manage.* **35**: 431–434.

Viraktamath, C. A. and Murphy, D. H. 1980. Description of two new species with notes on some Oriental Idiocerinae (Homoptera: Cicadellidae). *J. ent. Res.* **4** (1): 83–90.

Wagle, P. V. 1934. The mango hoppers and their control in the Konkan, Bombay Presidency. *Agric. Live-stock India*: 4: 176–188.

Entomon 22(2): 119–123 (1997)

Oribatid Mites from Lakshadweep - 1. A New Species of *Lepidacarus* csizar, 1961 (Acari: Lohmanniidae)

M. A. Haq* and N. Ramani

Division of Acarology, Department of Zoology
University of Calicut, Kerala - 673 635

Abstract: Several new species of oribatid mites belonging to various genera and families were collected during an expedition to Lakshadweep islands. In this paper, description of a new species of a rare genus, *Lepidacarus* is given. The new species was collected from coconut litter at Bengarum, one of the uninhabited islands of Lakshadweep.

Keywords: Oribatida, New species, Lakshadweep

INTRODUCTION

Lepidacarus represents a very rare genus of Lohmanniidae with a highly restricted distribution. The members of the genus are characterised by the possession of transverse suture on the genital plates, phylliform or spoon shaped setae on prodorsum and notogaster, strong neotrichy on epimeral region, separated nature of anal and adanal plates and a narrow pre-anal plate. Csizar (1961) erected the genus from Indonesian soils based on the type species, *L. ornatissimus*. Later, a subspecies, viz. *L. ornatissimus rehmabia* collected from a bamboo grove at the Zoological Gardens, Thiruvananthapuram, Kerala, India was added by Haq *et al.* (1983) as the second representative of the genus. The present species forms the third member of the genus.

***Lepidacarus ennarpi* sp. nov.**

Colour: Yellowish brown to brown.

Measurements: Length: 510 μm (Range: 510–561 μm)
Width: 281 μm (Range: 268–281 μm)

Prodorsum (Fig. 1)

Prodorsum broadly conical with a more or less pointed rostrum. Lateral margin of the prodorsum with a distinct tooth just above the insertion of *exa*. All prodorsal setae toothed, broad and palmate; seta *ro* placed far below anterior tip of rostrum; seta *le* inserted slightly below level but lateral to seta *ro*, erect and broad; seta *in* situated far

Received in February, 1997. *Corresponding author

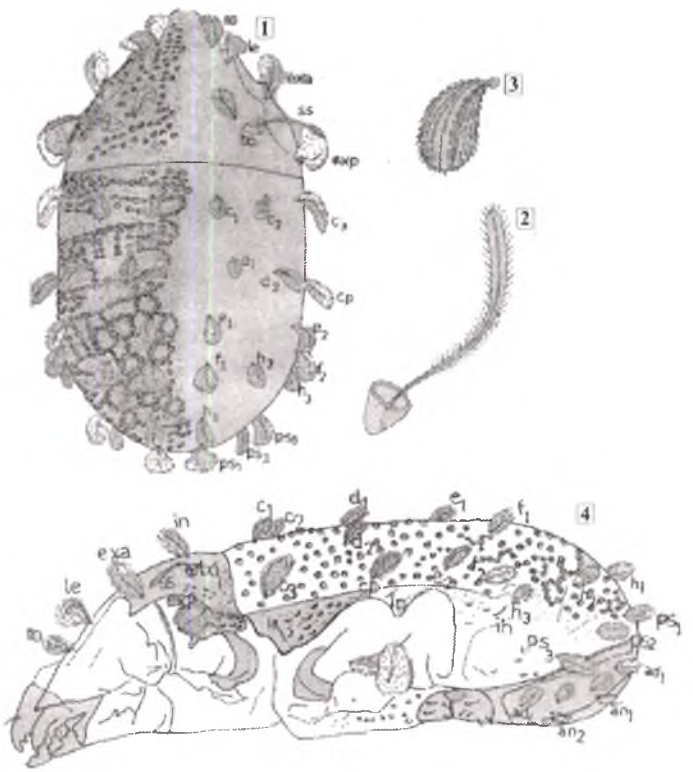


Fig. 1. Dorsal view; 2. Sensillus with bothridial cup; 3. Notogastral seta; 4. Lateral view.

below *le*, slightly above bothridial cups; setae *exa* and *exp* well spread out, inserted on lateral margin of prodorsum, *exp* more swollen than *exa*; setae *in*, *exa* and *exp* with basal tubercles; all prodorsal setae with distinct inner rachis. Bothridial openings wide, directed laterad through which stalk of sensillus (*ss*) issues out, *ss* gradually thickened distally assuming somewhat clavate appearance (Fig. 2) and bears barbs except at base, an inner core present throughout length of *ss*. Tubercles with chitinized boundaries present irregularly on prodorsum; prodorsal surface with punctations.

Notogaster (Fig. 1)

Notagaster broad, cylindrical with a slightly convex anterior border. 16 pairs of spoon shaped setae with distinct spines (Fig. 3) and of varying size arranged on notogaster, all setae bear an inner rachis, most of the marginal setae comparatively longer than median ones, c_3 longest and d_1 shortest, ps_1 well spread out. Notogaster bears tubercles with chitinous boundaries, arranged more or less linearly on the anterior region and forming a net work of somewhat circular beads posteriorly. Surface of notogaster also punctated.

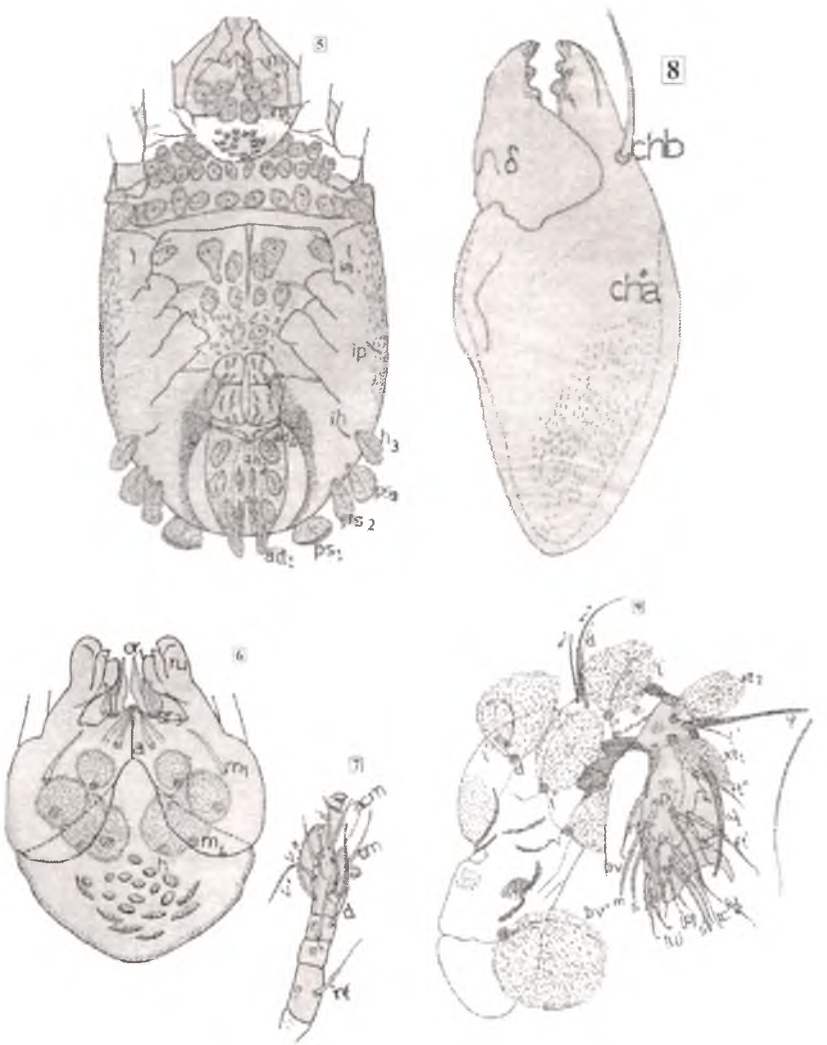


Fig. 5. Ventral view; 6. Gnathosoma; 7. Pedipalp; 8. Chelicera; 9. Leg - I.

Lateral region (Fig. 3)

Lateral surface of prodorsum without any specific ridges. Lateral tooth of prodorsal wall clearly visible. Antero-lateral corner of notogaster flexed ventrad into a compound apophysis bearing two projections, the posterior one more pronounced than the anterior one; this region bears lyrifissure *ia*. Median lateral wall of notogaster produced into another well developed and ventrally directed apophysis. Lyrifissures *ip* and *ih* located ventrally near *cp* and h_3 respectively.

Ventral region (Fig. 5)

Gnathosomal region (Fig. 6)

Labiogenal articulation stenarthric type. Infracapitulum with neotrichy, bearing 6 pairs of setae, of which m_2, m_3, m_4 and *h* spoon shaped while *a* and m_1 simple. Rutellum well developed with three blunt teeth. Mentum ornamented with tubercles and semilunar ridges below the level of seta *h*. Pedipalps (Fig. 7) five segmented with a chaetotaxy of 0-1-0-2-9(1). Chelicerae (Fig. 8) well developed with sclerotized digits bearing 2-3 teeth each, seta *chb* long and smooth while seta *cha* vestigial; a distinct blunt projection δ present on movable digit; body of chelicera porose.

Epimeral region

Epimeral plates with poorly developed apodemes; sejugal apodemes of two sides continuous medially. Setae of epimeral region palmate, spined and of varying size as shown in Fig. 5; epimeral setal formula 10-7-3-3. Fourth epimeral plate ornamented with foveoles and punctation.

Anogenital region

Anogenital plates separated by a narrow pre-anal plate, latter with a posteromedian excrescence. Genital plates divided by a transverse suture into a small anterior and a large posterior plate, each carrying 5 setae, anterior half of each genital plate carries a large, leaf like seta at the lateral border; inner to this, another leaf like but smaller seta present on anterior half of each plate; remaining three setae of the anterior half and all five setae of the posterior half barbed and thin. Anoadanal plates elongated and separated by a faint suture; anal setae 2 pairs, slender and barbed. Adanal setae 4 pairs, broad and barbed. Closely set foveoles and punctations border the anogenital region.

Legs

All legs monodactylous and punctated. Chaetotaxy of leg-1 (Fig. 9) 0-5-3(2)-3(1)-18(2); femur-1 carries 5 crescent shaped ridges, of which the largest one placed dorsolaterally while other four medially at lower half of segment, setae of femur spoon shaped, highly spread out and distinctly spined. Genu-1 bears 2 solenidia σ′ and σ″, latter longer than the former; seta 1′ of genu-1 spoon shaped, highly spread out and spined while 1″ normal and weakly barbed. Tibia-1 with two foliate setae xt_1 and xt_2, a slender smooth seta 1′ and a very long solenidion φ. Tarsus-1 with a total of 20 setae including 2 solenidia, ω_1 and ω_2, one famulus ε and 4 eupathidic setae, *m*″, *s*, *p*′ and *p*″.

MATERIALS EXAMINED

Holotype : ♂; paratypes : 3 ♂♂ and 2 ♀♀ collected from a mixture of coconut (*Cocos nucifera*) litter and soil, Bengarum, Lakshadweep islands on 10.x.1989. Coll: M. A. Haq. The holotype and paratypes at present are deposited in the Department of Zoology, University of Calicut.

REMARKS

The new species resembles the type species in the possession of palmate body setae, absence of pygidial neotrichy, presence of an epimeral setal formula of 10-7-3-3 and in the number and nature of genital and anoadanal setae. However, it is unique in several important respects namely the presence of a distinct median tooth on the lateral prodorsal margin, possession of a clavate sensillus with an inner core, arrangement of notogastral tubercles in network of linear and circular beads, possession of 6 pairs of infracapitular setae, of which 2 pairs (a) and (m_1) smooth and setiform while the remaining 4 pairs (m_2, m_3, m_4 and h) spined and palmate thereby establishing gnathosomal neotrichy and weakly developed nature of anoadanal suture.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial assistance rendered by the Department of Science and Technology, Government of India for conduct of the work.

REFERENCES

Csiszar, J. (1961) New oribatids from Indonesian soils (Acari). *Acta Zool. Sci. Hung.*, **7**: 345–366.

Haq, M. A., K. V. A. Mubarak and N. Ramani. (1983) New Lohmanniid mites (Acari: Oribatei) from Kerala, India. *Indian J. Acar.*, **8**(2): 87–94.

Entomon 22(2): 125–128 (1997)

Oribatid Mites from Coconut Palm - 6. A New Species of *Caloppia* balogh, 1958 (Acari: Oribatei)

N. Ramani* and M. A. Haq
Division of Acarology, Department of Zoology
University of Calicut, Kerala-673635

Abstract: An extensive survey covering different localities of Malabar on the oribatid mites harbouring the coconut palm, *Cocos nucifera* enabled to recover about two dozen species, of which several species appear to be new to science. In the present paper, morphological description of a new species of *Caloppia* belonging to the family caloppidae is included.

Keywords: Oribatid mite, Coconut palm, New species.

INTRODUCTION

The genus *Caloppia* was erected by Balogh (1958) with *C. basilewskyi* as the type species from the soils of Belgian Congo. In the same year he made further contribution to the genus by adding two more species viz. *C. papillata* and *C. minor* from Angola. Later, he (1959) added one more species, *C. vargai* from Eastern Africa. The occurrence of this genus from Rhodesian soils was reported by Mahunka (1973) who erected *C. longipilosa*. Corpuz-Raros (1979) recorded a new habitat, *i.e.*, the leaves of *Memecyclon caerulum* for *C. sottoetgarciai*. The present discovery of *C. sejugatus* sp. nov. from Kerala discloses new host plants such as *Cocos nucifera, Musa paradisiaca* and the weed, *Chromolaena odorata* for this genus. The genus is reported for the first time from India.

***Caloppia sejugatus* sp. nov. (Figs. 1-4)**

Colour : Dark brown to black.

Measurements : Length: 332 μm (Range : 319–383 μm)
Width : 268 μm (Range : 268–319 μm)

Prodorsum : (Fig. 1)

Prodorsum broader than long, narrowing towards rostral apex. Seta *ro* (Fig. 1a) thin, sharply pointed and barbed measuring 90 μm in length. Lamellae sheath-like, equally broad throughout except at base and provided with irregular reticulations; lamellae

Received in April, 1997. *Corresponding author

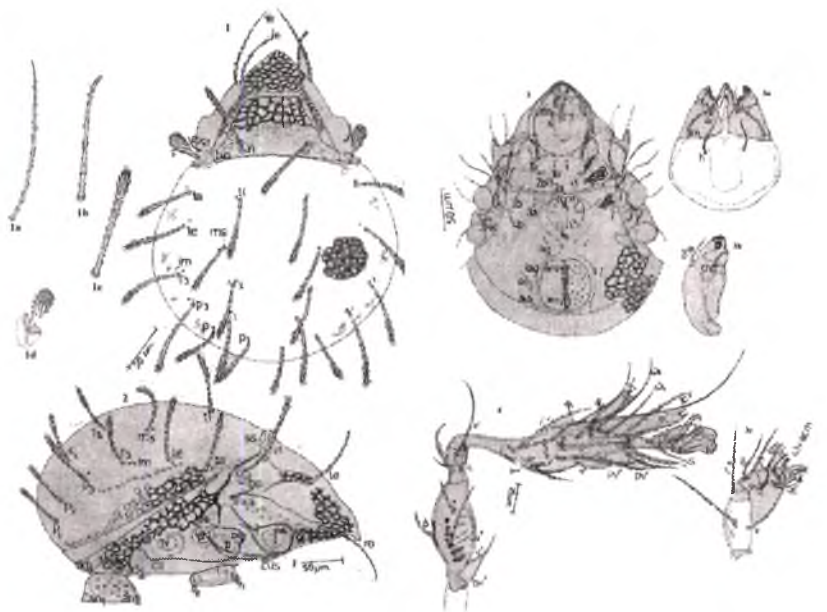


Fig. 1. *Caloppia sejugatus* sp. nov. – Dorsal region; 1a. rostral seta; 1b. lamellar seta; 1c. interlamellar seta; 1d. sensillus.
Fig. 2. *C. sejugatus* – Lateral region.
Fig. 3.*C. sejugatus* – Venteral region; 3a. gnathosoma; 3b. chelicera; 3c. pedipalp.
Fig. 4. *C. sejugatus* – Leg. I

of both sides connected medially by a rod shaped translamella with a wavy anterior margin; seta *le* (Fig. 1b) barbed, shorter than rostral hairs, measuring 73 μm and provided with blunt tip. Seta *in* (Fig. 1c) shorter, thicker than *le* measuring 70 μm and densely barbed, barbs short basally and long apically. Seta *exa* thin, barbed, inserted on lateral border of prodorsum, above level of bothridia. Bothridial cups (*bo*) widely open laterally and partly sunken within anterolateral corners of notogaster; sensillus (*ss*) (Fig. 1d) inserted deep into the bothridial cup and provided with smooth stalk and clavate, densely barbed head. Prodorsal surface lying anterior to translamella with imbricate pattern of reticulation and area posterior to translamella with two-dimensional feature, exhibiting reticulations in one plane and foveolae in another plane; the foveolae and reticulations diminish posteriorad and merge with punctations present at interlamellar area.

Notogaster: (Fig. 1)

Notogaster globular and broader than longer with anterior boundary marked by well developed dorsosejugal suture. Ten pairs of densely barbed and elongated setae arranged on notogaster, the shape of which resembles that of seta *in*; seta p_2 shortest and p_3 longest; all setae thickened towards tip. Five pairs of minute pores located on the notogaster in close association with setae *ta, te, ms*, r_3 and p_3. Fissure *im* placed more laterally, very near and above r_3. Sculpture of notogaster consists of polygonal to rounded foveolae of different dimensions. Integument of notogaster fuscous and

densely punctated.

Lateral region: (Fig. 2)

Tutorium well developed. Pedotecta I and II developed prominently and without any sculptures. Discidium (*dis*) and custodium (*cus*) well detected laterally. Circumpedal carina (*cir*) also well developed. No area porosae or alveoli on the lateral region of prodorsum.

Ventral region: (Fig. 3)

Gnathosoma (Fig. 3a)

Infracapitulum smooth and without any sculptures. Labiogenal articulation diarthric type. Setae *h* and *a* weakly barbed while seta *m* longer and thicker than *a* and *h* and with prominent barbs. Rutellum (*ru*) with four short notches. Chelicerae (Fig. 3b) smooth; seta *cha* longer than seta *chb*; digitus fixus with four and digitus mobilis with five sclerotised teeth. Pedipalps (Fig. 3c) small, five segmented and with a setal formula of 0–2–1–3–9; setae on palpal segments variously barbed; tarsus with three eupathidia and a solenidion (ω), *acm* closely associated with ω, *sul* not detected.

Epimeral region: (Fig. 3)

Apodemata III and IV not detected; apodeme II small; sejugal apodemata of both sides continuous medially. Epimeral setal formula 3-2-3-2; seta 1*c* largest, setae 1*c*, 3*c* and 4*c* thicker than others and with short barbs, all others roughened. Epimeral area foveolated and punctated.

Genital and anal regions: (Fig. 3)

Genital plates more sclerotised than general ventral surface; each genital plate slightly broadened anteriorly carrying six setae, g_1 and g_2 closely placed anteriorly, g_3 little behind g_2, g_4 shifted towards the lateral region, g_5 far posterior in the same vertical line with that of g_3, g_6 placed at extreme posterior and in same vertical line with that of g_1. A single pair of aggenital setae (*ag*) present posterolaterally, exterior to the sclerotized plate enveloping the genital plates. Anal plates long with sparse surface foveolation; each anal plate bears two smooth, short setae, one anteriorly and the other posteriorly placed. Only two pairs of adanal setae located, ad_1 at the posterolateral corner of the anal plate and ad_2 laterally placed below the level of an_2. Fissure *iad* located laterally, a little above the insertion of ad_2. Ventral plate reticulated and foveolated around the anal plates.

Legs

Legs heterodactylous, the central claw thicker than lateral ones and all three claws bear spines dorsally. Chaetotaxy of leg I (Fig. 4) 0–6–4–6–21. Femur I carries irregularly arranged batches of porose areas and faint striations, seta *d* barbed and thicker than others, *bv″* smooth. Genu I carries a solenidion (σ) and three barbed setae, 1′ longer than other two. Tibia I broadened distally with two solenidia, φ_1 and φ_2, former reaching more than twice in length of the latter, setae *v′* and *v″* with long barbs, 1′ and 1″ also barbed. Tarsus I carries the maximum number of setae including two solenidia (ω_1 and ω_2) and a famulus (ε); all tarsal setae except (*p*) and *s* barbed in various degrees.

Materials examined

Holotype : ♂; paratypes: 5♂♂ and 4♀♀ collected from the foliage of coconut palm, Calicut University Campus, Kerala, India on 18.11.84. Coll: N. Ramani. The holotype and paratypes are deposited in the Department of Zoology, University of Calicut for the time being.

REMARKS

C. sejugatus can be easily separated from *C. basilewskyi, C. papillata, C. minor, C. vargai* and *C. longipilosa* by the globular body, differences in the ornamentation of the prodorsum and notogaster and differences in the nature of sensillus and notogastral setae. *C. sejugatus* resembles the other known species, *C. sottoetgarciai* in the shape of the body, nature of sensillus, prodorsal and notogastral setae. However, it differs from *C. sottoetgarciai* in having a well developed translamella, presence of foveolae and reticulations on the prodorsal region below the translamella, complete nature of dorsosejugal suture, possession of 5 pairs of notogastral pores, epimeral setal formula of 3–2–3–2 and differences in the nature and arrangement of epimeral setae, difference in the arrangement of setae on the genital plates and in the presence of only two pairs of adanal setae.

REFERENCES

Balogh, J. (1958). Oribatides nouvelles de l' Afrique tropicale. *Rev. Zool. Bot. Afr.*, **58**(1-2): 1–34.

Balogh, J. (1959). Some oribatid mites from Eastern Africa (Acari: Oribatidae). *Acta Zool. Acad. Sci. Hung.*, **5**(2): 1–32.

Mahunka, S. (1973). Neue und interessante milbe aus dem Genfer Museum XI. Neue and Wenig bekannte Oribatiden aus Rhodesien (Acari). *Arch. Sc. Geneve*, **26**(3): 205–225.

Corpuz-Raros, L. A. (1979) Philippine Oribatei (Acarina) 1. Preliminary list of species and descriptions of 40 new species. *Philipp. Agric.*, **62**(1): 1–82.

Entomon 22(2): 129–133 (1997)

Biochemical Changes of Tukra Leaves of Mulberry and its Effect on Economic Characters of Mulberry Silkworm, *Bombyx mori* L.

G. Veeranna*

Entomology Unit, Karnataka State Sericulture Research and Development Institute, Thalaghattapura Bangalore – 560 062, India

Abstract: Pink mealybug, *Meconellicoccus hirsutus* (Green) affected mulberry leaves were bioassayed to determine the supporting ability for development of growth of silkworm, *Bombyx mori* L. compared to healthy ones. It was found that economical characteristics such as weight of ten larvae, effective rate of rearing (ERR), single cocoon weight, shell weight, shell percent, filament length, etc, were significantly high in silkworm fed with tukra leaves compared to larvae fed with healthy leaves. Some biochemical constituents such as moisture content, total lipids and fatty acids, soluble carbohydrates and proteins were analysed. Percentage of moisture, total lipids, total proteins and soluble carbohydrates were found high in tukra leaves compared to healthy ones.

Keywords: *Meconellicoccus hirsutus, Bombyx mori*, tukra, Biochemical.

INTRODUCTION

Pink mealybug, *Meconellicoccus hirsutus* (Green) is a common "hard to kill pest" of horticulture crops all over the world. Mulberry being a perennial crop and forms a sole food of silkworm, *Bombyx mori* L. which is affected by several insects, among them *M. hirsutus* is, of late, severe one (Dhahira Beeavi, 1991; Manjunath *et al.*, 1992). Mulberry plants affected with *M. hirsutus* show curling of leaves, thickening and flattening of stem at the growing point resulting in stunted growth of plants (Sriharan *et al.*, 1979). Since literature available (Thangamani and Vivekanandan, 1983; Pradip Kumar *et al.*, 1992) on the quality of tukra leaves and its biochemical constituents are scanty and controversy, the present investigation was undertaken to determine the suitability of tukra mulberry leaves as food to silkworm, *B. mori* and its biochemical constituents compared to healthy mulberry leaves.

Received in July, 1996.

*Corresponding author

MATERIALS AND METHODS

Mulberry garden of M5 variety and Dehra Dun (D.D.) variety were selected in Karnataka State Sericulture Research and Development Institute campus for conducting the bio-assay studies and for analysing the biochemical constituents between *M. hirsutus* affected mulberry leaves (tukra leaves) and healthy leaves. Five replications of one dfl's each of NB4D2 were reared using tukra and healthy leaves separately (Krishnaswamy, 1978) during 1995. However, larvae were given three feedings in 24 hr. The assesment of economic characters was made with regard to effective rate of rearing (ERR), single coccoon weight, shell weight, shell percent, filament length, etc.

To determine the biochemical constituents from tukra affected and normal leaves of M5 and D.D. varieties, tukra affected leaves from different regions of the plants were collected separately and in D.D. variety, tukra leaves collected only from apical region as we could not get sufficient leaves from other regions of the plants. Normal leaves of corresponding regions from the healthy plants were collected in near by regions of tukra affected plants in the same garden. Three replications of each constituent such as total lipids, soluble carbohydrates and proteins were analysed by adopting standard procedures of Folch *et al.* (1957), Dubais *et al.* (1956) and Lowry *et al.* (1951) respectively. Various fatty acids C12 to C18 were determined using Gas Chromatograph (Shimadzu – GC– 9A) after esterification of total lipids. Data were analysed statistically using "ANOVA".

RESULTS AND DISCUSSION

Effect of *M. hirsutus* affected mulberry leaves on the growth of silkworm and economic characteristics of cocoons with that of healthy leaves fed silkworms are presented in Table 1. Duration of silkworm larvae fed with normal leaves and tukra leaves was not significant (21 $\pm$ 1 day). Weight of ten matured larvae and effective rate of rearing (ERR) reared on tukra leaves was significantly high ($p<0.05$). Pradip Kumar *et al.* (1992) reported that weight of ten matured larvae and ERR were significantly less in tukra leaves fed larvae compared to the larvae fed with healthy leaves. Thangamani and Vivekanandan (1983) reported that no significant difference in weight of ten matured larvae and ERR between the larvae fed with tukra and healthy leaves.

Economic characters such as cocoon weight, shell weight, shell percent and length of filament were significantly high ($p<0.05$) in the cocoons harvested from the larvae fed with tukra leaves compared to healthy leaves (Table 1). No difference in these parameters was observed in the cocoons harvested from the larvae fed with tukra and healthy leaves (Thangamani and Vivekanandan, 1983). On the contrary, significant variations in these parameters was recorded by Pradip Kumar *et al.* (1992). In the present investigation, it is noticed that the fecundity and percentage of egg hatching were almost same from the moths emerged from the cocoons harvested from the silkworms reared on tukra leaves and healthy mulberry leaves.

Table 1
Economic characters of Cocoons raised by tukra and healthy mulberry leaves

Economic Characters	Healthy leaves	Tukra leaves	C. D. at 5%
Weight of 10 larvae (gm)	22.88	33.30	2.492
E. R. R	56.00	65.00	2.262
Single cocoon weight (gm)	1.04	1.32	0.115
Shell weight (gm)	0.17	0.22	0.020
Shell per cent	16.02	16.69	–
Length of filament (m)	965.00	1100.00	2.546
Fecundity (No.)	384.00	434.00	–
Hatching (%)	94.20	94.55	–

Table 2
Biochemical Constituents between Tukra and Healthy mulberry leaves

Variety of mulberry	Position of leaf	Moisture content %	Lipid content %	Carbohydrate content %	Protein content %
	Apical	70.58	3.63	6.20	14.36
M5	Middle	69.13	4.16	10.19	14.06
Healthy	Lower	66.97	1.23	9.36	15.37
	Apical	76.09	4.04	7.53	15.02
M5	Middle	72.22	4.96	12.50	15.09
Tukra	Lower	70.38	2.06	12.46	15.93
DD healthy	–	72.64	4.56	10.38	25.57
DD tukra	–	77.30	4.30	11.90	19.56
C.D. at 5% of M5	–	1.146	0.356	0.619	0.112
C.D. at 5% of D.D	–	1.635	–	–	0.856

Some biochemical constituents such as total lipids, total proteins and carbohydrates and fatty acids were analysed from the tukra and healthy mulberry leaves (Table 2 and 3). Percentage of moisture content, total lipids, total proteins and soluble carbohydrates were significantly more ($P<0.05$) in tukra leaves of M5 variety compared to that of healthy ones. No significant variations of total lipids and carbohydrates was recorded in the D.D. variety of tukra and healthy leaves. However, percentage of moisture content was significantly high in tukra leaves of D.D. variety (Table 2). But, the total proteins content was found same in all the plant regions of tukra leaves of M5 variety because of the fact that the stunted growth of the mealybug infested plant and

phytotoxemic effect on the tukra leaves might be the reasons. Similarly, no significant variations was observed in the fatty acids content excepting palmitic acid and linolic acid which are less and lenolenic acid is high in the tukra affected leaves compared to healthy leaves of M5 and D.D. varieties (Table 3). Umesh Kumar *et al.* (1990) showed biochemical constitutents of tukra and healthy leaves varied from one variety to another. Thangamani and Vivekanandan (1983) reported that the moisture, total lipids, total proteins and carbohydrates are more or less same in tukra and healthy mulberry leaves.

Table 3
Fatty acids content (%) of tukra and healthy mulberry leaves

Position/ treatment	Lauric acid (C 12)	Myristic acid (C 14)	Palmatic acid (C 16)	Stearic acid (C 18)	Oleic acid (18:1)	Linolic acid (18:2)	Lenolenic acid (18:3)
Normal Upper M5	0.08	0.09	17.62	4.27	2.02	19.04	56.04
Normal Middle M5	0.15	0.54	18.21	4.94	1.31	19.93	54.94
Normal Bottom M5	0.19	0.88	18.86	4.03	1.82	18.68	55.50
Tukra Upper M5	0.21	0.52	14.87	4.64	2.80	13.89	63.04
Tukra Middle M5	0.14	0.05	13.93	4.25	3.57	13.98	64.05
Tukra Bottom M5	0.26	0.54	13.57	4.70	4.70	12.36	63.89
Nornal DD	0.58	0.10	22.48	5.60	1.24	23.57	46.40
Tukra DD	0.37	0.75	18.27	4.20	1.34	24.50	50.54

It is evident from the results that the mealybug, *M. hirsutus* affected mulberry leaves are no way inferior to healthy leaves as food of silkworm, *Bombyx mori* L. Tukra leaves have comparable nutritive value as that of healthy leaves. However, the yeild of mulberry leaves is reduced in mealybug affected plants depending on the intensity of infestation (Veeranna, unpublished). Tukra leaves have more moisture content and almost similar nutritive value because of phytotoxemic effect of mealybug on biochemical constitutents and anatomical features compared to healthy leaves. Sericulturists, therefore, can feed the tukra leaves of mulberry to the silkworms which may not affect the silkworm growth.

ACKNOWLEDGEMENT

Author is thankful to Dr. M. R. Nirmala, Research Assistant and Mr. Manjunathgowda, Research Fellow, KSSRDI, Bangalore–62 for their assistance in carrying out

this study. He is grateful to the Director and Division Chief, Sericulture Division, KSSRDI, Bangalore–62 for facilities provided and encouragement. Department of Science and Technology, New Delhi, Government of India is gratefully acknowledged for financial assistance.

REFERENCES

Dhihira Beevi, N. (1991). Mulberry mealybug a hard to kill pest. *Indian Silk*, **30**(3): pp.31.

Dubais, M. K., T. A. Giller, I. K. Hamilton, P. A. Readers and F. Smith (1956). Calorimetric method for determination of sugars and related substances. *Annals of Chemistry*, **28**: 350–336.

Folch, J., M. Lees and G. H. S. Stanley (1957). A simple method for isolation and purification of total lipids from animal tissue. *Journal of Biochemistry*, **226**: 497–509.

Krishnaswamy, S. (1978). New Technology of silkworm rearing. CSR & TI. *Bulletine, 2*, Mysore, India.

Lowry, O. H., N. J. Rosebrough, A. L. Farr and R. J. Randall (1951). Protein measurement with folinphenol reagent. *Journal of Biological Chemistry*, **193**: 256–275.

Manjunath, D., Ram Kishore, K. Sathya Prasad, K. Vinod Kumar, P. Kumar and R. K. Datta (1992). Biology of mulberry mealy bug and predatory potential of its biocontrol agent. National Conference on Mulberry Sericulture, **10** and **11** December, 1992, pp.50.

Pradip Kumar, Ram Kishore, M. K. R. Noamani and K. Sengupta (1992). Effect of feeding tukra affected mulberry leaves on silkworm rearing performance, *Indian Journal of Sericulture*, **31**(1): 27–29.

Sriharan, T. P., M. V. Samson and S. Krishnaswamy (1979). Studies on the tukra disease (*Meconellicoccus hirsutus*) on mulberry. *Indian Journal of Sericulture*, **18**: 78–80.

Thangamani, R. and M. Vivekanandan (1983). Effective utilisation of tukra diseased mulberry leaves of silkworm, *Bombyx mori* L. feeding. *Sericologia*, **23**(4): 211–223.

Umesh Kumar, N. N., M. P. Shree, Muthegowda and G. Boraiah (1990). Changes in proteins, sugars, phenols and total chlorophyll content of mulberry plant affected by tukra. *Indian Journal of Sericulture*, **29**(1): 93–100.

Entomon 22(2): 135–139 (1997)

Insecticidal Action of Some Plant Extracts Against *Albizia* Defoliator, *Rhesala imparata* Walker (Lepidoptera: Noctuidae)

N. Kulkarni* and K. C. Joshi

Tropical Forest Research Institute, Jabalpur 482 021, India

Abstract: Efficacy of methanolic extracts of seeds of *Azadirachta indica* and leaves of *Aloe vera*, *Lantana camara* var. *aculeata*, *Datura matel*, *Ipomoea carnea* ssp. *fistulosa* and *Annona squamosa* was evaluated against the larvae of *Rhesala imparata*, in laboratory. Seed extract of *A. indica*, leaf extracts of *A. squamosa* and *L. camara* were effective at/above 3.0 per cent. These extracts caused highest mortality at 5.0 per cent concentration *i.e.*, 84.35, 81.07 and 84.45 per cent, respectively. These were followed by *I. carnea* leaf extract with 60.78 per cent, *D. matel* with 54.74 per cent mortality at the same concentration. Leaf extract of *Aloe vera* was least effective.

Keywords: Plant extracts, insecticidal property, *Rhesala imparata*, botanical pesticides.

INTRODUCTION

The environmental hazards posed by synthetic chemical insecticides have necessitated the search for some alternative source of natural origin for applying ecologically viable pest control strategies. The botanical extractives are one of these alternatives owing to their short term persistence in the environment. During last five decades, more than 2000 plant species belonging to different families and genera, especially higher plants (Arnason *et al.*, 1989) have been reported to contain biologically active principles with multifacial effects against various insects (Grainge and Ahmed, 1988). The neem tree (*Azadirachta indica* A. Juss.) leads them with the large amount of work carried out (Schmutterer, 1995). There are some texts and general reviews on other insecticidal plants (Singh, 1993; Devkumar and Parmar, 1993). Most of the studies till date have been restricted to agricultural pests and no such studies have been conducted against forest insect pests in India except against *Atteva fabriciella* (Ahmed *et al.*, 1991) and *Clostera cupreata* (Ahmed *et al.*, 1996). There are several reports on insecticidal property of neem (*A. indica* A. Juss) elsewhere in abroad against some broad leaved and coniferous insects (Skatulla) and Meisner, 1975; Speckbacher, 1977; Beitzen–Heineke and Hofmann, 1992). In view of the above the present work was carried out to test the efficacy of methanolic plant extracts of seeds of *Azadirachta indica* A. Juss. (Neem), leaf extract of *Aloe vera* – Cruz Mill (Elephant Aloe), *Lantana camara* var. *aculeata*

Received in January, 1997. *Corresponding author

Mold. (Raimuniya), *Datura matel* (Dhatura), *Ipomoea carnea* (Jacq.) ssp. *fistulosa* (Austin) (Beshram Booti) and *Annona squamosa* Linn. (Seetaaphal) against the larvae of *Rhesala imparata* (Lepidoptera : Noctuidae) which has been reported sometimes to be troublesome in plantations of *Albizia lebbeck* and *A. procera* in many states of India including Andaman islands (Beeson, 1941; Bhasin and Roonwal, 1954).

MATERIALS AND METHODS

The leaves of *A. vera, L. camara, D. matel, I. carnea, A. squamosa* and seeds of *A. indica* were collected, shade dried and powdered. Extracts were prepared using a "Soxhlet Apparatus" by exposing 50 gms of each material with 500 ml of methanol as solvent. Residue obtained after evaporation of the solvent was redissolved in methanol to prepare 10 per cent stock solution, which was used to prepare further dilution of 1.0, 3.0 and 5.0 per cent of each extract in distilled water. A few drops of Triton X-100 (but so as to maintain its concentration below 0.02%) were added as emulsifier.

Larvae of *R. imparata* were collected from the seedlings and plantations raised at Tropical Forest Research Institute, Jabalpur and culture was maintained in laboratory. Only freshly moulted penultimate instar larvae were used. The larvae were starved prior to the experiment as per the standard methods to equalize their physiological conditions. Ten larvae were taken in petridishes of 10 cm diameter and sprayed with 2 ml solution of each concentration of plant extracts under Potter's tower (Potter, 1952) at 1.09 Kg/cm^2 pressure. One set was sprayed only with distilled water + Triton X-100 and another remained untreated as control. Each treatment was replicated thrice. Insects were then transferred to cylindrical plastic containers with fresh food and mortality records were noted after 24, 48 and 72 hours. Immovable and moribund larvae were counted as dead. The mortality in control was corrected using Abbott's formula (Abbott, 1925) and data were subjected to statistical analysis by ANOVA method and means were compared by Duncans Multiple Range Test (DMRT) (Duncan, 1951).

RESULTS AND DISCUSSION

Results indicate that seed extract of *A. indica*, leaf extracts of *A. squamosa* and *L. camara* were effective. The mortality recorded at 24, 48 and 72 hours at various concentrations of extracts has been summarized in Table 1. Leaf extract of *A. squamosa* was the most effective at 5.0 per cent concentration after 72 hrs which killed 81.07 per cent larvae and was at par with seed extract of A. indica at the same concentration which killed 84.35 per cent ($P<0.05$). It was followed by leaf extract of *L. camara* with 84.45 per cent and *I. carnea* with 60.78 per cent larvae after 72 hrs. Leaf extracts of *D. matel* and *A. vera* were least effective with only 54.74 and 41.75 per cent larval kill at 5.0 per cent extracts. At lower concentrations of 3.0 per cent *A. indica* caused highest mortality followed by *L. camara, A. squamosa, I. carnea* and *A. vera*. The larvae have shown dose dependent response against the extracts tested (Table 1).

Table 1
Mortality recorded in the larvae of *Rhesala imparata* treated with plant extracts

Plant species	Concen-tration	Mortality recorded after hrs (%)*			Total* mortality (%)
		24	48	72	
Aloe vera	1.0	18.64 e	2.82 e	0.00 e	21.47 g
Leaves		(25.00)	(5.65)	(0.00)	(27.45)#
	3.0	22.03 d	15.25 c	3.33 d	40.56 e
		(27.87)	(22.68)	(6.14)	(39.53)
	5.0	38.98 bc	2.82 e	0.00 e	41.75 e
		(38.46)	(5.65)	(0.00)	(40.23)
Lantana camara	1.0	11.86 f	6.21 e	0.00 e	18.08 h
var.*aculeata*		(19.81)	(8.51)	(0.00)	(23.84)
Leaves	3.0	35.59 c	9.04 d	6.66 d	51.24 d
		(36.50)	(14.16)	(8.85)	(45.65)
	5.0	42.37 b	25.42 ab	16.66 a	84.45 a
		(40.59)	(30.19)	(23.85)	(67.00)
Datura matel	1.0	2.82 h	6.21 e	0.00 e	9.04 j
Leaves		(5.65)	(8.51)	(0.00)	(10.45)
	3.0	5.65 g	6.21 e	3.33 d	15.20 i
		(11.30)	(8.51)	(6.14)	(18.14)
	5.0	19.20 ef	32.19 a	3.33 d	54.74 d
		(21.68)	(33.36)	(6.14)	(48.00)
Ipomoea carnea	1.0	9.04 g	2.82 e	0.00 e	11.86 i
var. *fistulosa*		(14.16)	(5.65)	(0.00)	(16.10)
Leaves	3.0	18.64 e	15.81 c	6.66 c	41.13 e
		(24.18)	(19.35)	(12.29)	(38.56)
	5.0	22.03 d	25.42 b	13.33 ab	60.78 c
		(27.87)	(29.37)	(21.14)	(52.11)
Annona squamosa	1.0	9.04 g	0.00 f	16.66 a	22.37 fg
Leaves		(14.16)	(0.00)	(23.85)	(28.09)
	3.0	25.42 d	15.25 c	3.33 d	44.01 e
		(30.20)	(22.14)	(6.14)	(41.39)
	5.0	42.42 b	19.26 ab	16.66 a	81.07 a
		(40.52)	(30.19)	(23.36)	(67.12)
Azadirachta	1.0	15.25 ef	9.04 d	3.33 d	27.62 f
indica Seeds		(22.68)	(14.16)	(6.14)	(31.11)
	3.0	49.15 a	6.21 e	13.33 b	68.69 b
		(44.40)	(8.51)	(17.70)	(56.94)
	5.0	52.54 a	15.25 c	16.66 a	84.35 a
		(46.46)	(22.14)	(23.85)	(67.27)
	F ratio	4.15	3.18	7.78	9.19

* Each value represents mean corrected mortality in three replications.
# Values in parentheses are arc sin $\sqrt{}$ transformations of percentage values.
a Values followed by same letters within a collumn are statistically equivalent ($P>0.05$) by DMRT (Duncan, 1951).

It is evident from the above that *A. squamosa* and *L. camara* posses insecticidal property and could play a greater role in pest management programs. Although, there are no such studies reported on *R. imparata* to compare but the similar study on the insecticidal property of botanical extracts have been reported against mahaneem web worm, *Atteva fabriciella* by Ahmed *et al.*, (1991). They have tested efficiency of extract of *Acorus calamus*, rhizome and leaf extracts of *Lantana camara, Adhatoda vasica* and *Melia azedarach* against the larvae of *A. fabriciella* and mortality was recorded after 24 hours. They found all the extracts were effective at 2.0 per cent. Leaf extract of *L. camara* killed 66.66 per cent larvae at 5.0 per cent. Ahmed *et al.* (1996) tested various solvent extract of different parts of *Dalbergia stipulacea* and leaf extract of *Adina cordifolia* at concentrations ranging from 0.5 to 2.0 per cent against *C. cupreata*.

Some plants have a good insecticidal value and can be of great economic importance against various insect pests, after their due evaluation, in future. These plant extracts can safely be used initially in nursery stages and young plantations against this pest, if not as the only control method but alternatively with synthetic pyrethroids as per the strategy of integrated pest management, which does not advocate complete replacement of synthetic insecticides but allows their judicious use to circumvent the various problems posed by their prolonged application.

ACKNOWLEDGEMENTS

Authors are thankful to Shri. R. B. Lal, Director and Shri. R. L. Srivastava, coordinator (research) Tropical Forest Research Institute, Jabalpur for the facilities provided.

Authors are thankful to Dr. N. Rama Rao, Scientist, Forest Botany Division, Tropical Forest Research Institute, Jabalpur for timely identification of the plant species.

REFERENCES

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *J. Econ. Ent.*,**18**: 265–267.

Ahmed, Mukhtar, Rameshwar Dayal and Puspa Borai (1996). Evaluation of insecticidal properties of *Dalbergia stipulacea* against poplar defoliator, *Clostera cupreata* (Lepidoptera: Notodontidae). *Ann. For.*, **4**(1): 47–51.

Ahmed, Mukhtar, B. K. Gupta and R. S. Bhandari (1991). Efficacy of some plant extracts against *Ailanthus* webworm, *Atteva fabriciella*. *Indian Journal of Forestry*. **14**(1): 5–7.

Arnason, J. T., B. J. R. Philogene and P. Morand (1989). Insecticides of plant origin. *ACS Symp. Ser.*, **387** American Chemical Society, Washington D.C. 213 pp.

Beeson, C. F. C. (1941). *The ecology and control of forest insects of India and neighbouring countries.* Vasant Press, Dehra Dun, 1007pp.

Beitzen–Heineke, I. and R. Hofmann (1992). Versuche zur Wirking des azadirachtin haltigen, formulierten Niemsamen extraktes AZT–VR–NR auf *Hylobius abietis* L., *Lymentria monacha* L. and *Drino inconspicua. Meig. 2 Pflakrankh. PflSchulz*, **99**: 337–348.

Bhasin, G.P. and M. L. Roonwal (1954). List of insect pests of forest plants in India and the adjacent countries. *Indian Forest Bulletin*, **171**(1): (NS) (Entomology). 93pp.

Devkumar, C. and B. S. Parmar (1993). Pesticides of higher plant and microbial origin. In: *Botanical and Biopesticides* (Eds. B. S. Parmar and C. Devkumar) SPS India and Westwill Publishing House, New Delhi, **4**: pp. 1–73.

Duncan, D. B. (1951). A significance test for differences between ranked treatments in an analysis of variance. *Va. J. Sci.*, **2**: 171–189.

Grainge, M. and S. Ahmed (1988). *Hand book of plants with pest control properties*, A Wiley Interscience Publications, John Wiley and Sons, New York 470 pp.

Potter, C. (1952). An improved laboratory apparatus for applying direct sprays and surface films with data on the electrostatic charges on atomized spray fluids. *Ann. Appl. Biol.*, **39**(1): 1–28.

Schmutterer, H. (1995). (Ed.) *The neem tree,* ***Azadirachta indica*** *A. Juss and other meliaceous plants: sources of unique natural products for integrated pest management medicine, industry and other purposes*. VCH Publications, Weinheim, New York. 696pp.

Singh, R. P. (1993). Botanical pesticides in developing countries, current status and future trends. In: *Pesticides, their economic impact in developing countries* (Eds. G. S. Dhaliwal and Balwinder Singh), Commonwealth Publishers, New Delhi, India.

Skatulla, V. U. and J. Meisner (1975). Labor–Versuche mit Neimsamen produkten beim Waldmaikafer, *Melolontha hippocastani* (Coleoptera, Scarabaeidae). *Mitt. Forstl. Versuchs–u. Forsh. –Anst. Baden-Warttemb.* **132**: 103–108.

Speckbacher, U. (1977). Zur Wirking von Inhaltstaffen aus *Azadirachta indica* A. Juss (Meliaceae) auf einige Insektenarten, Diploma thesis, University of Munich, Germany.

Entomon 22(2): 141–145 (1997)

Short Communication

A Note on the Mosquito Fauna of Kochi and its Adjoining Islands in Kerala

T. Mariappan,* N. Arunachalam, N. Somachary and C. M. R. Reddy

Vector Control Research Centre, Medical Complex, Indira Nagar, Pondicherry 605006

Abstract: Kochi city in Kerala state is unique in its geographical position surrounded by islands with vast stretches of marshy lands and mangrove forest inundated with backwater, and other man-made habitats providing a variety of breeding sources for different species of mosquitoes, including vectors of human diseases. Kochi has been made a vulnerable focus, as it attracts tourists and traders from all over India and abroad, some of which are rated as highly endemic for mosquito borne diseases (WHO, 1995). Studies on the mosquito fauna and their breeding habitats are prerequisites for designing appropriate mosquito control measures and hence this study.

Keywords: Kochi, Mosquito Fauna, breeding habitats.

Kochi is situated, between 9° 58″ N latitude and 76° 14″ E longitude on the west coast of Kerala. The total area of Kochi and its adjoining islands (Bolgatty, Chellanam, Gundu, Kumbalalangi, Raman thurthy, Vallarpadam, Vypeen and Wellington) is approximately 120 Sq. km. with a population of over 6,50,000. The entire city is situated in the low land region.

A tropical humid climate prevails with small variation in temperature in different months of the year (22.2°C in Jan-32.6°C in May). Kochi is under the influence of both southwest and northeast monsoons, with an annual rainfall of about 3,000 mm.

A year long survey was carried out for mosquito breeding habitats. Mosquito immatures were collected, following the standard methods using dipper/bucket depending on the nature of different breeding habitats (Service, 1971) and the immatures were reared to adults in the laboratory. Indoor and outdoor resting mosquitoes and human landing/biting mosquitoes were also collected, using aspirators and torch. Both immatures and adult collections were made following the stratified random sampling procedures (Service, 1971). Larvae and adults were identified with the help of keys provided by Christophers (1933) and Barraud (1934). The present taxonomical status of various species were confirmed with the catalogue by Knight and Stone (1977).

Mosquito species obtained through different collections are listed in Table 1. 98.63% of the total mosquitoes was contributed by perennial habitats viz., drains, canals, coir-pits, casuarina pits, mangrove pools, cement tanks, wells, ponds, cess pools and septic

Received in February, 1997.

*Corresponding author

Table 1
Mosquito Species Recorded in Kochi and its Adjoining Islands in Kerala

Sl. No.	Species	Breeding habitats	Species					
			Emergence		Resting		Biting	
			No.	%	No.	%	No.	%
01.	*Aedes (Aedimorphus) vittatus* (Bigot) 1861	CT,GS & TS	10	0.011	–	–	21	0.036
02.	*Aedes (Stegomyia) aegypti* (Linnaeus) 1762	BO,CS,CT,DR,EP,GS MP,TH,TI,TS,TY,WE & WMC	432	0.046	8	0.0094	14	0.024
03.	*Aedes (Stegomyia) albopictus* (Skuse) 1994.	BO,CS,CT,DR,FP,GS MP,TH,TI,TS,TY, WE & WMC	811	0.87	32	0.038	202	0.347
04.	*Anopheles (Anopheles) barbirostris* Van der Wulp 1884	CA & PO	486	0.522	–	–	4	0.0069
05.	*Anopheles (Anopheles) hyrcanus gr.*	CA & PO	356	0.382	–	–	2	0.0034
06.	*Anopheles (Cellia) jamesii* Theobald 1901	Po & WE	38	0.041	–	–	8	0.014
07.	*Anopheles (Cellia) splendidus* Koidzumi 1920	PO	2	0.0021	–	–	–	–
08.	*Anopheles stephensi* Liston 1901	CT,OHT & WE	167	0.179	–	–	4	0.0034
09.	*Anopheles (Cellia) subpictus* Grassi 1899	CA,CAP,COP,CT,PO & WE	593	0.637	4790	5.62	654	1.122
10.	*Anopheles (Cellia) vagus* Doenitz 1902	CA,CAP,COP,CT,PO & WE	112	0.12	56	0.066	15	0.026
11.	*Armigeres (Armigeres) subalbatus* (Coquillett) 1889	CD,CT,GS,MP,ST,TS & TY	4312	4.63	1482	1.74	1373	2.36

Sl. No.	Species	Breeding habitats	Species					
			Emergence		Resting		Biting	
			No.	%	No.	%	No.	%
12.	*Culex (Barraudius) modestus* Ficalbi 1889	PO	3	0.0032	–	–	2	0.0034
13.	*Culex (Culex) bitaeniorhynchus* Giles 1901	CAP & PO	147	0.158	7	0.008	6	0.01
14.	*Culex (Culex) cornutus* Edwards 1922	PO	9	0.0097	–	–	–	–
15.	*Culex (Culex) epidesmus* Theobald 1910	PO	4	0.0043	–	–	1	0.0017
16.	*Culex (Culex) gelidus* Theobald 1910	CAP,COP,CD & PO	467	0.501	64	0.075	384	0.659
17.	*Culex (Culex) quinquefasciatus* Say 1823	CA,CD,CP,CT,DR,MP,ST TI,TS,TY,WE & WMC, CAP	81715	87.72	276	0.324	16447	28.22
18.	*Culex (Culex) sitiens* Wiedemann 1828	CA,CAP,CD,COP	2498	2.682	78443	92.11	35131	60.28
19.	*Culex (Culex) tritaeniorhynchus* Giles 1901	Po & WE	293	0.314	–	–	47	0.081
20.	*Culex (Culex) univittatus* Theobald 1901	CAP	2	0.0021	–	–	–	–
21.	*Culex (Culex) vishnui* Theobald 1901	PO & WE	294	0.316	5	0.006	44	0.076
22.	*Culex (Culex) whitmorei* (Giles) 1904	PE & PO	15	0.016	2	0.0023	3	0.0052
23.	*Culex (Eumelanomyia) brevipalpis* (Giles) 1902	CT & WE	172	0.185	–	–	–	–
24.	*Culex (Lophoceraomyia) minutissmus*	Po & WE	8	0.0086	–	–	–	–

Sl. No.	Species	Breeding habitats	Species					
			Emergence		Resting		Biting	
			No.	%	No.	%	No.	%
	(Theobald) 1907							
25.	*Culex (Lutzia) fuscanus* Wiedemann 1820	CD,COP,CT & PO	102	0.109	–	–	15	0.026
26.	*Mimomyia (Mimoyia) chamberlaini* Ludlow 1904	PO	16	0.017	–	–	–	–
27.	*Mimomyia (Mimomyia) hybrida* Leicester 1908	PO	8	0.0086	–	–	–	–
28.	*Mansonia (Mansonioides) annulifera* Theobald 1901	PO	23	0.025	–	–	2554	4.38
29.	*Mansonia (Mansonioides) indiana* Edwards 1930	PO	9	0.0097	–	–	86	0.148
30.	*Mansonia (Mansonioides) uniformis* Theobald 1905	PO	12	0.013	–	–	1264	2.17
31.	*Uranotaenia (Pseudoficalbia) atra* Theobald 1905	PO	7	0.0075	2	0.0023	–	–
32.	*Uranotaenia (Uranotaenia) habes* Barraud 1931	PO	5	0.0054	–	–	–	–
33.	*Uranotaenia (Uranotaenia) orientalis* Barraud 1926	PO	13	0.014	–	–	–	–
34.	*Uranotaenia (Uranotaenia) testacea* Theobald 1905	PO	9	0.0097	–	–	–	–
35.	*Orthopodomyia flavithorax*	PO	2	0.0021	–	–	–	–

Abbreviations: BO - Bottles; CP - Cess Pits; GS - Grinding Stones; PF - Paddy Fields; TS - Tree Stumps; CA - Canals; CS - Coconut Shells; MAP - Mangrove Pools; PO - Pools/Ponds; TY - Tyres; CAP - Casuarina Pit; CT - Cement Tanks; ML - Marshy Lands; ST - Septic Tanks; WE - Wells; CD - Cement Lined Drains; DR - Drums; MP - Mud Pots; TH - Tree Holes; WMC - Water Meter Chambers; COP - Coir Pits; FP - Flower Pots; OHT - Over Head Tanks; TI - Tins

tanks; and the rest by the seasonal habitats such as tyres, mudpots, water meter chambers, flower pots, tree stumps, tree holes etc.

A total of 35 species of mosquitoes belonging to eight genera from the emergence of immatures, 12 species of 5 genera from indoor resting collection and 24 species of 5 genera from man landing collections were obtained. Some of the mosquitoes of public health importance in order of their abundance include: *Culex quinquefasciatus* (87.72%), *Aedes aegypti* (0.46%), *Cx. tritaeniorhynchus* (0.31%), *Cx. vishnui* (0.31%), *Anopheles stephensi* (0.18%), *Mansonia annulifera* (0.03%), *Ma. uniformis* (0.01%) and *Ma. indiana* (0.01%). Among the nuisance mosquitoes, *Armigeres subalbatus* (4.63%) is predominant, followed by *Cx. sitiens* (2.68%). All other mosquitoes receive little importance from the public health point of view.

This study reveals the presence of vector mosquitoes of various communicable diseases viz., filariasis, malaria, dengue and Japanese encephalitis in Kochi and its adjoining islands. Since the breeding habitats of different mosquito species are well defined, control measure against any specific mosquitoes is certainly a positive preposition.

ACKNOWLEDGEMENTS

The authors are thankful to late Dr. Vijai Dhanda, former Director and Dr. P. K. Das, Director, Vector Control Research Centre, Pondicherry for their encouragement and suggestions. Thanks are also due to Dr. K. N. Panicker and Dr. S. Sabesan for their guidance in this study. The assistance rendered by the Technical staff, VCRC, Kochi field Station and the Field workers of Kochi Corporation are gratefully acknowledged.

REFERENCES

Barraud, P. J. (1934). The fauna of British India including Ceylon and Burma. *Vol. 1st ed.* (Taylor and Francis). p 463.

Christophers, S. R. (1933). The fauna of British India including Ceylon and Burma. *Vol. IV 1st ed.* (Taylor and Francis). p 371.

Knight, K. L., and A. Stone (1977). A catalogue of the mosquitoes of the world. (Diptera: Cullicidae), *2nd ed.* (The Thomas Say Foundation, Mary land). p 611.

Service, M. V. (1971). Studies on sampling larval populations of the *Anopheles gambiae* complex. *Bull. WHO.*, 45: p 169.

World Health Organization. (1995). Vector Control for Malaria and other Mosquito-borne diseases. *WHO Technical Report Series* 857. p 93.

Entomon 22(2): 147–149 (1997)

Short Communication

Pediobius foveolatus Craw (Eulophidae: Hymenoptera) a potential parasitoid on the grubs of egg plant spotted beetle *Henosepilachna vigintioctopunctata* Fab.

B. Rajendran*[1] and M. Gopalan[2]

[1]*Associate Professor of Entomology, Sugarcane Research Station (TNAU), Cuddalore 607001*

[2]*Director, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore 641003*

Abstract: The studies made at Sugarcane Research Station, Cuddalore in Tamil Nadu during 1993-95 revealed the predominant prevalence of the larval parasitoid *Pediobius foveolatus* Craw. (Eulophidae: Hymeptera) on the late instar grubs of the egg plant spotted beetle *Henosepilachna vigintioctopunctata* (Fab) (Coccinellidae: Coleoptera). Though the parasitization of *P. foveolatus* was found throughout the year, maximum natural parasitization on spotted beetle to 49.5, 49.1 and 47.1 per cent was recorded during August 1993, November 1994 and September 1993 respectively. The parasitization was found to be highest in fourth instar stage. This parasitoid could be potentially used for the management of the spotted beetle in egg plant.

Keywords: Parasitoid, *Pediobius foveolatus*, egg plant, spotted beetle.

Egg plant (*Solanum melongena* Linn.) a common vegetable of India is widely cultivated in Tamil Nadu. Among the major insect pests, the spotted beetle, *Henosepilachna vigintioctopunctata* Fab. caused extensive damage to the foliage (Krishnamurti and Appanna, 1951). The severe damage causes out right death of young plants. In grown up plants, the yield is highly reduced (Sambandam *et al.* 1972).

Though insecticidal control is the immediate and effective way to manage this beetle, the toxic residues left on egg plant, warrant alternate strategies like biocontrol with least interference to environment.

The studies conducted during 1993-95 on egg plant at Sugarcane Research Station, Cuddalore in the South Arcot Vallalar district of Tamil Nadu, an area for prominent vegetable cultivation, revealed the predominant prevalence of larval parasitoid *Pediobius feveolatus* Craw. (Eulophidae: Hymenoptera) on the late instar grubs of the spotted beetle *H. vigintioctopunctata*. The study on population of host and parasitoid was carried out in egg plant (Annamalai variety) in plots of size 5×4 m maintained from August 1993 to July 1995. Successive plots were planted when the former experimental plot was 125 days old and maintained in full growth of uniform age during the

Received in February, 1997. *Corresponding author

Fig. 1. Population of *Henosepilachna* and its parasitization by *Pediobius foveolatus* during August 1993 to July 1994

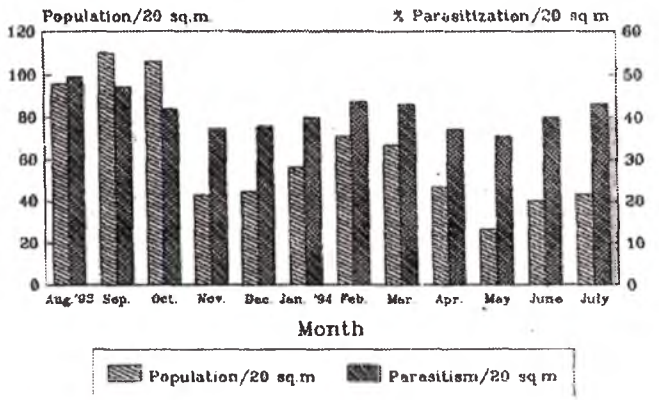
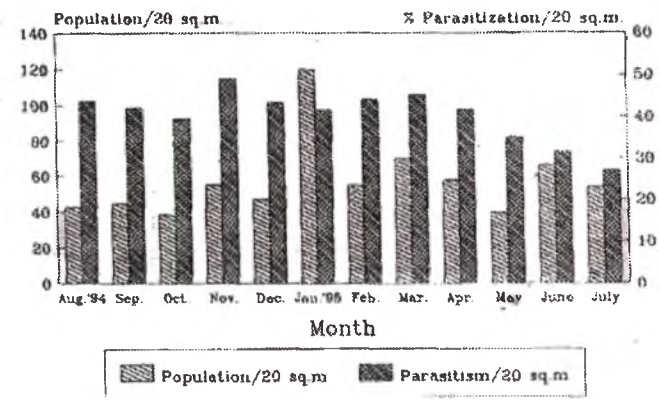


Fig. 2. Population of *Henosepilachna* and its parasitization by *Pediobius foveolatus* during August 1994 to July 1995



period of study. Six such plots were thus maintained and population of grubs and their parasitization by *P. foveolatus* were recorded during every fortnight in each plot, and the mean worked out per 20 m^2 monthwise.

The parasitization of grubs was found throughout the period of study. Among the different months during 1993-95, the maximum parasitization of beetle grubs by *P. foveolatus* was recorded in August 1993 (49.5%), November 1994 (49.1%) and September 1993 (47.1%) (Fig. 1 and 2). The percentage parasitization was also found to exceed 40% during October 1993, January to March, 1994, June to September 1994, December 1994 and January to April, 1995. During July 1995, the parasitization was only 26.9%. Maximum parasitization was noticed in the third and fourth instar grubs. The data on the parasitization of spotted beetle proved that *P. foveolatus* parasitized late instar grubs throughout the year, provided the crop is in the field continuously sustaining the host population. During most of the period of study, parasitization exceeding 40 per cent was recorded indicating the potentiality of the parasitoid on the

host.

This parasitoid was recorded earlier as *Pleurotropis foveolatus* Craw, (Lal 1946). The other host records of this parasitoid were *Epilachna varivestis* Mulsant. (Stevens *et al.*, 1975), *Epilachna philippinensis* (Chiu and Moore, 1993), *Epilachna vigintioctomaculata* (Paik, 1991) and *Epilachna ocellata* F. (Dhamdhere and Dhingra, 1990). Lal (1961) and Mathur and Srivastava (1964) reported that efficient parasitization of 35–70 per cent grubs occurred in field especially on third and fourth instar grubs of *E. vigintioctopunctata*. These findings are also in confirmation with the present study. It could be inferred that the parasitoid might be potentially used as a bio control agent to check spotted beetle damage in egg plant as well as on its alternate hosts.

REFERENCES

Chiu, C. H. and A. Moore. (1993). Biological control of the Philippines lady beetle, *Epilachna philippinensis* (Coleoptera; Coccinellidae) on solanaceous plants by the parasitoid *Pediobius foveolatus* (Hymenoptera: Eulophidae) on Saipan. In Biological control of Exotic Pests in the Pacific. *Proceedings of a Plenary Session and Symposium, XIX International Congress of Entomology*, Beijing, June 1992. **4**: 79–80.

Dhamdhere, S. V. and M. R. Dhingra, (1990). Natural enemies of *Epilachna ocellata*. *J. Ent. Res.*, **14**(2): 192–193.

Krishnamurti, B. and M. Appanna, (1951). Occurrence, distribution and control of major insect pests of some important crops in Mysore. *Mysore Agric. J.*, **27**: 1–23.

Lal, B. (1946). Biological notes on *Pleurotropis foveolatus* Crawford a larval parasite of *Epilachna vigintioctopunctata* (Fab.) *Curr. Sci.*, **15**: 138–139.

Lal, B. S. (1961). On the biology of *Pediobius foveolatus* Crawford (Eulophidae: Hymenoptera) *Indian J. Ent.* **23**: 268–273.

Mathur, A. C. and J. B. Srivastava, (1964). *Epilachna vigintioctopunctata* as a defoliator of some solanaceous medicinal plants. *Indian J. Ent.*, **26**: 246.

Paik, J. C. (1991). Notes on some *Entedoninae* (Hymenoptera, Chalcidoidea, Eulophidae) in Korea. *Insecta Koreana* **8**: 60–75.

Sambandam, C. N., V. Sivasubramanian, S. Chelliah, and K. Natarajan, (1972). Scheme for evaluation of egg plant varieties for resistance to the spotted beetle (*Epilachna vigintioctopunctata* F.) the aphid (*Aphis gossypii* G.) and little leaf virus. *Final Report, Faculty of Agriculture, Annamalai University*, p. 118.

Stevens, L. M., A. L. Steinhaus and J. R. Coulson, (1975). Suppression of Mexican bean beetle on soybeans with annual inoculative releases of *Pediobius foveolatus*. *Environ. Entomol.*, **4**: 947–952.

Entomon 22(2): 151–155 (1997)

Short Communication

Feeding behaviour of *Nephotettix virescens* (Distant), a vector of Tungro virus on rice varieties with different level of resistance

A. K. Chowdhury* and S. Biswas

Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, Nadia, West Bengal, 741 252

Abstract: Rate of xylem and phloem feeding of tungro vector *Nephotettix virescens* (Distant) on leafhopper resistant (IR50) moderately resistant (Khitish and Rashi) and susceptible (TN1) rice varieties have been tested by caged method. Rate of xylem feeding was more in IR50 while TN1 and Khitish had maximum phloem feeding as measured on the basis of excreted honeydew. Fasting of insect did not have any significant difference on xylem feeding in TN1 but at 9 hr of fasting it increased the rate of phloem feeding. A minimum variation was observed by male and female insect in respect to xylem and phloem feeding.

Keywords: Leafhopper, feeding, xylem and phloem, tungro virus, rice.

Rice green leafhopper (GLH) *Nephotettix virescens* (Distant) is an important pest of rice, causing direct damage by sucking sap from the vascular tissues and indirect damage by transmitting number of virus and mycoplasma diseases. Rice tungro virus disease (RTVD) is one of the most important diseases and it caused either by joint or single infection of rice tungro spherical virus (RTSV) and rice tungro bacilliform virus (RTBV) (Hibino 1983) and transmitted most efficiently by *N. virescens* and few other species of leafhopper, in semipersistent manner (Ling 1972) which is influenced by feeding mode and host resistance. Feeding behaviour of *N. virescens* and tungro transmission have been studied more critically by various workers which suggested that *N. virescens* primarily sucks plant sap through phloem and xylem in susceptible varieties and mostly on xylem tissues in resistant rice varieties (Khan and Saxena 1984; Auclair *et al.* 1982).

Interaction of virus, host and vector play a significant role to understand the ecology of RTVD specially when there is an involvement of two types of viruses. This study was conducted under laboratory conditions with the objectives to understand the feeding behaviour of *N. virescens* in respect to rice varieties having different grades of susceptibility to vector and virus, sex of GLH and influence of fasting time in feeding behaviour which might help on the epidemiological studies of this important disease.

Feeding behaviour of *N. virescens* was tested using TN1 (Taichung Native 1), IR50, Khitish (IET4094) and Rashi (IET1444) varieties of rice having different levels of

Received in October, 1996. *Corresponding author

susceptibility to virus and leathopper vectors. Besides, feeding behaviour of male and female *N. virescens* of same age, their effect on fasting time on feeding was also measured using standardized techniques (Pathak and Heinrichs 1982; Auclair *et al.* 1982). Rice seedlings keeping one per pot were raised separately in the green house and 7 days old seedlings were used for test feeding. Insects of same age collected from the rearing cages were placed in the potted seedlings covered with mylar cages at the rate of one GLH per plant for 24 hrs. and honeydew excreted from a single insect was trapped in bromocresol-green treated filter paper disk placed around the base of the seedlings. Honeydew droplets while coming in contact with the treated filter paper developed spots of different colour and size. Blue spots (basic reaction) were assumed to indicate phloem feeding and orange or brown spots (acidic reaction) were assumed to indicate xylem feeding. Honeydew excreted by GLH was quantified by measuring the area of acidic and basic spots on the filter paper using a graph paper and counting the number of squares present within the areas of various spots and expressed in mm^2. Rice varieties used for the experiment included TN1 as susceptible to GLH while IR50, as resistant and Khitish (IET4094), Rashi (IET1444) have moderate resistance to both of RTV and GLH vector. Each treatment was replicated for five times following the method of randomized complete block design.

Feeding behaviour of GLH was compared for 24 hrs using four rice varieties under caged conditions in room temperature and results are presented in Table 1. A variation was noticed in xylem and phloem feeding of the confined GLH and the highest average xylem feeding upto 51.00 mm^2 observed in IR50 and in phloem it was only 7.4 mm^2. In TN1 variety which is susceptible for GLH had maximum (35.6 mm^2) phloem feeding with minimum (5.6 mm^2) xylem feeding. Feeding pattern of leafhopper in xylem tissues did not differ significantly within the cultivars like TN1, Khitish and Rashi. Higher rate of xylem feeding in comparison to phloem as observed with IR50 suggesting the resistance nature of the variety. Cultivar Rashi had almost equal preference of feeding both in xylem and phloem. Variety IIR50 was screened against rice tungro virus and its GLH vector both in laboratory and field conditions in different locations and observed a low virus infection as compared to TN1 (Dahal and Hibino 1985; Hibino *et al.* 1987).

Table 1
A comparison on the rate of xylem and phloem feeding under caged condition by a single *N. virescens* on four rice varieties

Variety	Feeding Area (mm^2)	
	Xylem	Phloem
TN1	5.6	35.6
IR50	51.0	7.4
Khitish	9.0	34.0
Rashi	17.4	15.6
CD(5%)	30.95	17.23

Honeydew excreted during feeding on TN1 seedlings by individual GLH after different period of fasting have been measured to determine the rate of xylem and phloem feeding. An area of 32.4, 17.6 and 58.0 mm^2 of phloem feeding and 31.6, 25.8 and 27.4 mm^2 of xylem feeding recorded at 3, 6 and 9 hrs of fasting respectively (Table 2). Variation on xylem feeding was not significantly different but apparently a higher rate of xylem feeding was observed at 3 hrs after fasting. Further, it appears that at early stage of fasting GLH feed both the tissues almost equally which suggesting that GLH had no preference at initial stage of fasting. Rice tungro virus is semipersistently transmitted by leafhopper vector and preacquisition starving increased the transmission efficiency of vector (Mukhopadhyay and Chowdhury 1973). Exposure of longer feeding time may allow the vector to probe both xylem and phloem which may enhance the possibilities of virus acquisition and transmission in both resistant and susceptible rice varieties.

Table 2
A comparison on the rate of xylem and phloem feeding by a single *N. virescens* after different period of fasting on GLH susceptible TN1 variety

Fasting period (hrs)	Feeding Area (mm^2)	
	xylem	Phloem
3	31.6	32.4
6	25.8	17.6
9	27.4	58.0
CD (5%)	15.42 (ns)	22.97

ns = non significant

Feeding pattern of male and female *N. virescens* on TN1 and IR50 varieties recorded a significant variation only in respect of varieties and host tissues. Intensity of xylem feeding was more in IR50 while TN1 showed more phloem feeding (Table 3). Feeding by male and female insects in IR50 and TN1 varieties did not differ significantly. Irrespective of sex and variety interaction, *Nephotettix* female always had high feeding preference than male insects. Female of GLH in general are the most efficient tungro transmitter than the male (Shukla 1979) and this study also established the higher feeding capacity by female insects irrespective of xylem, phloem or varieties which supported the views for higher tungro transmission by female GLH than the male. Resistance of rice plant against GLH can be measured by different methods (Saxena 1986) of which feeding behaviour is one of the criteria which can be used to identify the host resistance and virus transmission in an efficient manner.

It is now well established that transmission of RTBV or RTSV is related with the GLH feeding and in general GLH feed mostly on xylem in resistant varieties and predominantly infected with RTBV. RTSV is independently transmitted and causing mild symptoms but RTBV transmission by GLH is dependent on RTSV and causing severe disease symptoms. Rice crop in the field may be infected either by individually or jointly by any of the viruses by GLH transmission. Transmission of tungro viruses

Table 3
A comparison on xylem and phloem feeding by male and female *N. virescens* separately on a GLH susceptible and resistant rice varieties

Treatments	Feeding area (mm^2)	
	Xylem	Phloem
Variety		
TN1	6.2	29.8
IR50	30.7	3.4
CD(5%)	19.59	11.26
Sex		
Female (F)	26.9	18.7
Male (M)	10.0	14.5
CD(5%)	19.59 (ns)	11.26 (ns)
Interaction		
TN1 × F	7.4	33.5
TN1 × M	5.0	26.2
IR50 × F	46.4	4.0
IR50 × M	15.0	2.8
	CD(5%) 27.71 (ns)	15.92 (ns)

ns = non significant

in the field not only depends on the host resistance but simultaneously with the feeding behaviour of GLH. All such information will help to breed rice varieties resistance to both vector and virus.

ACKNOWLEDGEMENTS

The second author is thankful to the Indian Council of Agricultural Research for providing financial assistance in the form of junior fellow to conduct the study.

REFERENCES

Auclair, J., E. Baldos, E. A. Heinrichs (1982). Biochemical evidence for the feeding site of leafhopper *Nephotettix virescens* within susceptible and resistant rice plant. Insect. Sci. Appl. **3**: 29–34.

Dahal, G. and H. Hibino (1985). Varieties with different resistance to tungro (RTV) and green leafhopper (GLH) Int. Rice Res. News1. **19**(1): 5–6.

Hibino, H. (1983). Relation of rice tungro bacilliform and rice tungro spherical viruses with their vector *Nephotettix virescens*. Ann. Phytopathol. Soc. Jpn. **40**: 545–553.

Hibino, H., E. R. Tiongco, R.,C. Cabunagan and Z. M. Flores (1987). Resistance to rice tungro associated virus in rice under experimental and natural condition. Phytopathology. **77**: 871–875.

Khan, Z. R. and R. C. Saxena (1984). Techniques for demonstrating phloem and xylem feeding by leafhopper (homoptera: Cicadellidae) and planthoppers(Homoptera: Delphacidae) in rice plant J. Eco. Entomol. **77**: 550–552.

Ling, K. C. (1972). Rice virus diseases. Int. Rice Res. Inst. Los Bonos, Philippines, 142 pp.

Mukhopadhyay, S. and A. K. Chowdhury(1973). Some epidemiological aspects of tungro virus disease of rice in West Bengal. Int. Rice. Comm. News1. **22**(4): 44–57.

Pathak, P. K. and E. A. Heinrichs (1982). Bromocresolgreen indicator for measuring feeding activity of *Nilaparvata lugens* on rice varieties Philip. Entomol. **5**(2): 195–198.

Saxena, R. C. (1986). Biochemical basis of insect resistance in rice varieties. In Green B and P. A. Hedin (eds) Natural resistance of plants to pests: Roles of Allelochemicals. Acs. Symposium. Ser. **296**: 142–159.

Shukla, V. D. (1979). Studies on the epidemiology of rice tungro virus disease. Ph. D. thesis Utkal University, Bhubaneswar, India. 249 pp.

Entomon 22(2): 157–158 (1997)

Short Communication

Behaviour of *Anopheles barbirostris* before, during and after total solar - eclipse

S. N. Chatterjee and G. Chandra*

Department of Zoology, Burdwan University
Burdwan 713104, West Bengal, India

Abstract: Behaviour of unfed, halffed, fullfed, halfgravid and fullgravid *Anopheles barbirostris* was studied before, during and after total solar-eclipse which occurred on 24.10.95 in India. Total solar-eclipse brought about interesting changes in their behaviour. But their behaviour during total solar-eclipse was more or less similar to that in a cloudy day or when they were kept in an artificial shade.

Keywords: Solar-eclipse, *Anopheles barbirostris*, behavioural changes.

Anopheles barbirostris Vander Wulp (Diptera: Culicidae) is a recognised vector of human filariasis (Raghavan, 1969; Das, 1976). Japanese encephalitis virus has been isolated from this species from different parts of India (Hati, 1981). The study was designed to study the effect of a total solar-eclipse (one of the most important events of the present century) on the behaviour of *A. barbirostris* at panskura, West Bengal, India, where the total solar-eclipse persisted for 1 mi and 15 sec between 8.15 a.m. and 9 a.m. on 24.10.95.

Out of three hundred *A. barbirostris* collected from cattlesheds, 15% were full gravid, 9% half gravid, 21% unfed, 7% half fed and 48% full bloodfed. Mosquitoes of each category were kept separately in 5 large cages.

A similar set of mosquitoes was used as control. A white rat was kept in each cage after placing it in a wire net. Two pots filled with water and a petridish containing a piece of cotton soaked with glucose solution were also placed in each cage. All the cages were placed in sunlight at 6 a.m. Five experimental cages were kept under sun up to 4 p.m. The control cages were transferred to an artificial shady place just at the onset of solar-eclipse and it was again transferred carefully to sunlight after the completion of solar-eclipse. The behaviour of mosquitoes before, during and after solar-eclipse was observed, recorded and presented in Table 1. According to earlier observations (Pradhan *et al.* 1993), *A. barbirostris* used to breed in shady places. When the control cages were transferred to an articial shady place from sunlight, more or less similar behavioural changes of mosquitoes were noted like those kept in experimental cages during solar-eclipse as described in Table 1. Afterwards, the experiments were repeated in the same manner on a dark cloudy day which also reflected more or

Received in April, 1997.

*Corresponding author

Table 1
Behaviour of *A. barbirostris* before, during and after solar-eclipse

Mosquitoes	Number tested	Before solar-eclipse (6 am.m-8.15 a.m)	During solar-eclipse (8.15 a.m-9 a.m)	After solar-eclipse (9 a.m-4 p.m)
Full gravid	45	95% in resting condition 5% in flying condition	96% started egg laying 4% in resting condition	same observations were recorded as
Half gravid	27	90% in resting condition 10% in flying condition	92% active flying 8% in resting condition	before Solar-eclipse in all cases
Unfed	63	20% in resting condition 80% in flying condition	85% of them started blood sucking 15% in flying condition	
Half fed	21	100% in resting condition	78% active flying 22% blood sucking	
Full fed	144	100% in resting condition	100% in resting condition	

less similar behaviour. Totality of solar-eclipse brought about interesting behavioural changes in mosquitoes such as, most of the resting gravid females started egg laying, resting half gravid females became restless, unfed females engaged in blood sucking and a portion of the half-fed females became interested for their second blood meal and the rest of these became restless. But the changes were not very significant because the solar-eclipse acted more or less like an artificial or a natural shade.

REFERENCES

Das, M. (1976). Vectors of filaria with special reference to India. *J. Com. Dis.*, 8: 101–109.

Hati, A. K. (1981). Vectors of Japanese encephalitis in India and their bionomics and control. *Bull. Cal. Sch. Trop. Med.*, **23**: 87–88.

Pradhan, S., G. K. Saha, B. Dasgupta and A. K. Hati (1993). Distribution and ecology of anopheline fauna in hilly regions of India. An overview. *J. Beng. Nat. Hist. Soc.*, **12**: 11–68.

Raghavan, N. G. S. (1969). A review of epidemiology of filariasis in India. *J. Com. Dis.*, **1**: 153–194.

Entomon 22(2): 159–160 (1997)

Short Communication

Ceuthorrynchus portulacae Marshall (Coleoptera: Curculionidae) A Potential Biological Control Agent of *Portulaca oleracea*, L.

P. N. Ganga Visalakshy* and K. P. Jayanth

Division of Entomology and Nematology
Indian Institute of Horticultural Research
Bangalore 560 089, India

Abstract: *Portulaca oleracea* is a serious weed attacking 45 crops in 81 countries. A curculionid leaf miner *Ceuthorrhynchus portulacea* was found attacking the weed in many parts of Southern India. Preliminary studies indicated that the insect possesses many of the attributes of a potential biocontrol agent. Importation and releases of this insect could prove beneficial in suppressing the weed in other countries.

Keywords: *Ceuthorrhynchus portulacae, Portulaca oleracea*, potential biocontrol agent.

Portulaca oleracea L. (Portulacaceae), a plant of European origin is considered as a serious weed of 45 crops in 81 countries. The weed is reported to have allelopathic effects to crops plants, toxicity to live stocks and act as alternate hosts to economically important pests and pathogens [Holmes *et al.* 1977]. In India, it is a serious weed of vineyards, banana orchards, vegetables, cotton, groundnut, soybean, chillies etc., [Shanmugavelu, *et al.* 1985, Mandal, 1990].

Regular surveys in different parts of Southern India, showed the occurrence of a leaf-miner attacking the weed, identified as *Ceuthorrhynchus portulacae* Marshall (Coleoptera: Curculionidae). The adults are active, pale brownish on emergence, turning darker or black coloured later. Eggs are laid beneath the leaf epidermis and larval stages feed within leaf mines. A maximum of 4 larvae were observed feeding on a leaf. In the absence of food, the larvae were noticed to emerge and enter fresh leaves, buds and even tender stems. On maturation, full grown larvae drop to the ground and pupate within chambers formed in the soil. Laboratory studies showed that the insect completed its life cycle in 13-15 days at 24 ± 2°C and 60-80% RH. The adults were found to live up to 2 months with an average fecundity of 290/ (range 114–453). The insects were collected throughout the year in Bangalore; where the temperature ranges between 19.2-35.2°C. The larval and adult feeding caused complete defoliation of the

Received in April, 1996.

*Corresponding author

weed in horticultural fields within 30-45 days after its appearance, whereby suppressing its competitive ability with other plants.

Suryes for biological control agents carried out in South America, U. S. A., Europe, Africa, and Asian countries revealed feeding by 15 different species of insects on *P. oleracae*. Further detailed studies carried out on three insects viz. *Baris archithorax* Pic., *Hypyrus bertrandi* Perris., and *Schizocerella pilicornis* Holmgren showed that only *S. pilicornis* was capable of suppressing the weed in various vegetable fields situated in the hot interior areas (Awadallah *et al.* 1980, Clement and Norris, 1984).

C. portulacae appears to possess many of the attributes of a good biological control agent, such as occurrence throughout the year, wide temperature tolerance, short life cycle, prolonged longevity, high fecundity and capacity to suppress the weed. Importation and releases of this insect into other countries is likely to provide promising results.

ACKNOWLEDGEMENTS

Authors are grateful to Dr. V. V. Ramamurthy, Senior Scientist, I.A.R.I., New Delhi, India, for identifying the insect and Director, I.I.H.R., for encouragement.

REFERENCES

Awadallah, K. T., M. F. S., Tawfik and F. F. Shalaby (1980). Notes on the life history of *Baris archithorax* Pic. on the weed *Portulaca oleraceae* L. *Bull. Ent. Soc. of Egypt*, **60**: 35–43.

Clement, L. S. and F. R. Norris (1984). Two insects offer potential biological control of common purslane. *Calif. Agriculture*, **38**: 16–18.

Holmes, L. G., D. L. Pluknett, J. V. Pancho and J. P. Herberger, (1977). *The world's worst weeds: Distribution and biology*. Univ. Press, Hawaii, Honolulu, 609 pp.

Mandal, R. C. (1990). *Weed, Weedicides and Weed Control - Principle and Practice*. Publ. by Agro Botanical Publishers, India, 114pp.

Shanmugavelu, K. G., R. Aravindan and A. Rajagopal (1985) *Weed management of Horticultural Crops*. Publ. by Agro Botanical Publishers, India, 236 pp.

Entomon 22(2): 161–163 (1997)

Short Communication

Suppression of Spherical Mealybug, *Nipaecoccus viridis* (Newstead) (Homoptera: Pseudococcidae) on Jack fruit

M. Mani* and A. Krishnamoorthy

Division of Entomology and Nematology
Indian Institute of Horticultural Research
Bangalore - 560 089, India

Abstract: The spherical mealybug, *Nipaecoccus viridis* (Newstead), a sporadic but often a severe pest on jack fruit *Atrocarpus heterophyllus* Lam. was, suppressed by the encyrtid parasitoid *Anagyrus dactylopii* (How.) and the drosophilid predator *Cacoxenus perspicax* (Knab) within a month.

Keywords: Spherical mealybug, *Nipaecoccus viridis*, jack fruit, suppression, natural enemies

As many as 38 species of insects are known to attack jack fruit *Artocarpus heterophyllus* Lam. in India. Four mealybugs including two pseudococcids *Nipaecoccus viridis* (Newstead) and *Ferrisia virgata* (Ckll.) and two margarodids *Drosicha mangiferae* (Green) and *D. stebbingi* (Green) have been recorded earlier on jack fruit (Butani, 1979; Ghosh and Ghosh, 1985). Severe infestation of the spherical mealybug *N. viridis* was observed on the shoots of jack fruit during March'96 around Bangalore. They suck the sap, leading to drying of shoots. Insecticidal applications are not normally practiced for pest control on jack fruit. Mealybugs being sessile are more amenable for biological control. Hence, the effectiveness of local natural enemy complex was assessed in the suppression of *N. viridis*.

Severe mealybug infestation was noticed in the first week of March, 1996. Preliminary sampling indicated the activity of natural enemies. The natural enemy complex consisted of a primary parasitoid, *Anagyrus dactylopii* (How.) (Encyrtidae, Hymenoptera), an hyperparasitoid, *Promuscida unfaciativentris* Girault (Aphelinidae, Hymenoptera) and a drosophilid predator, *Cacoxenus perspicax* (Knab). These natural enemies were collected from all the three samples during March. A maximum of 16.45 and 1.53 of *A. dactylopii* and *C. perspicax* respectively from the samples were collected on 8th March and 21st March respectively (Table 1).

Received in April, 1997.

*Corresponding author

Table 1
Nipaecoccus viridis and its natural enemies on Jack fruit

Date of sampling	No. of healthy mealybugs/shoot (*N. viridis*)	No. of natural enemies emerged/shoot (Mean ± S.D.)	
		A, dactylopii	*C. perspicax*
8-3-1996	24.96±3.18	16.46±2.52	0.42±0.14
18-3-1996	16.15±2.47	15.07±2.02	1.53±0.37
27-3-1996	0.10±0.02	0.58±0.23	0.22±0.03

S.D - Standard Deviation

Mealybug population declined from 24.96 on 8th March to 0.10 on 27th March. The suppression of the spherical mealybug was mainly attributed due to the build-up of the natural enemies especially *A. dactylopii*. Similar kind of natural biological suppression of *N. viridis* on coffee in India (Chacko and Singh, 1980), citrus in Iraq (Abdul-Rasoul, 1970) and on ber in India (Mani, 1993) had been documented earlier. The present study was completed within a month. There was not much variation in the weather parameters like temperature, humidity and rainfall during this short period of study. Hence, the disappearance of mealybug population completely within a month was mainly due to the activity of bioagents. Chacko and Singh (1980) also reported the quick suppression of *N. viridis* by the natural enemies on coffee in Chikamagalur district of Karnataka. *A. dactylopii* played a major role in successfully controlling *N. viridis* on jack fruit in the present study. According to Zimmerman (1948), heavy population of *N. viridis* disappeared in Hawaii due to introduction of *A. dactylopii*. Noyes and Hayat (1994) reviewed the hosts of *A. dactylopii* and commented on its use as biological control agent. *C. perspicax* had been earlier merely reported as predator of several species of mealybugs in India and elsewhere. However, the predation by *C. perspicax* on *N. viridis* was observed throughout February in the present study.

It is concluded that the local natural enemy complex consisting of *A. dactylopii* and *C. perspicax* was found more than adequate to control *N. viridis* on jack fruit around Bangalore.

ACKNOWLEDGEMENTS

The authors are grateful to Director, IIHR, for providing facilities to conduct the study and Dr. M. Hayat, Aligarh Muslim University for identifying the parasitoids.

REFERENCES

Abdul-Rasoul, M. S. (1970). Notes on *Nipaecoccus vastator* (Maskell) (Coccidae), a pest of citrus trees and various plants. *Bull. Iraq Nat. Hist. Mus.*, 4: 105–106.

Butani, D. K. (1979). Insects and Fruits. Periodical Expert Book Agency, New Delhi, 415 pp.

Chacko, M. J. and M. B. Singh (1980). A note on the natural control of *Nipaecoccus viridis* on coffee in India. *J. Coffee Res.*, **10**: 63–64.

Ghosh, A. B. and S. K. Ghosh (1985). Effect of infestation of *Nipaecoccus vastator* (Maskell) on host plants. *Indian Agric.* **29**: 141–147.

Mani, M. (1993). Studies on mealybugs and their natural enemies in ber orchards. *J. Biol. Control*, **7**: 75–80.

Noyes, J. S. and M. Hayat (1994). Oriental mealybug parasitoids of the Anagyrini (Hymenoptera: Encyrtidae). CAB International, London. 554 pp.

Subba Rao, B. R., H. S. Sangwan, Q. A. Abbasi, Y. Singh and A. M. Kseersagar (1965). New records of hymenopterous parasites of *Nipaecoccus vastator* (Maskell) (Homoptera, Coccidae), a serious pest of citrus spp. from India. *Indian J. Ent.*, **27**: 109–110.

Zimmerman, E. C. (1948). Insects of Hawaii. Volume V, University of Hawaii Press, 464 pp.

Entomon 22(2): 165–166 (1997)

Short Communication

Incidence of ant associated mealy bug, *Xenococcus annandalei* (Homoptera: Pseudococcidae) on grapes in South India

B. K. Rajagopal, C. A. Viraktamath* and V. Nache Gowda

Department of Entomology and Horticulture, University of Agricultural Sciences, GKVK, Bangalore 560065, India

Abstract: The ant associated mealy bug, *Xenococcus annandalei* Silvestri is reported causing economic damage to grape vine (var. Bangalore Blue) around Bangalore. The mealy bug sucks the sap from rootlets and the affected vines show reduced vigour, shortening of fruit bearing canes, reduction in size of fruit bunches and yield. The insect is also recorded on roots of *Oxalis latifolia* H. B. (Oxalidaceae), *Euphorbia hirta* L. (Euphorbiaceae), *Blepharis mollinginifolia* Pers. (Acanthaceae) and *Ageratum conyzoides* L. (Asteraceae).

Keywords: Grape vine root mealy bug, *Xenococcus annandalei*, alternate hosts.

Grape vine (*Vitis vinifera* L.) is an important fruit crop grown around Bangalore both for table purpose and for manufacture of wine. Apart from the regular insect pests such as flea beetle, *Scelodonta strigicollis* (Motschulsky), thrips, *Rhipiphorothrips cruentatus* Hood, chafer beetles, *Holotrichia* spp. and stem girdler, *Sthenias grisator* (Fabricius), a few mealy bugs and scale insects also infest the vine (Nair, 1986). In the recent past, pink mealy bug, *Maconellicoccus hirsutus* (Green) has become a serious pest of the vine (Mani, 1989).

We found a grape vine garden at Singanayakanhally (about 22 km N. of Bangalore on Hindupur Road) severely infested by an aphid-like root mealy bug during November 1995. The garden had about 15 years old grape vine of the variety Bangalore Blue. Of the 110 vines, 35 vines on the eastern and northern border showed infestation. Infested vines could be easily made out by their sparse foliage and reduced vigour. They had shortened fruit bearing canes measuring 25-30 cm long instead of normal 60-75 cm. The grape bunches on the affected vines were also reduced. The farmer harvested an yield of only 2 tonnes instead of regular yield of 4-5 tonnes in previous years when the pest was not observed. The mealy bug was later identified as *Xenococcus annandalei* Silvestri, a subterranean myrmecophilous mealy bug described originally from Barkuda Island, Chilka lake in Orissa by Silvestri (1924).

Adult female mealy bugs are pale white, small, measuring 1.5 mm in length, with tapering abdomen which is curved up and long four segmented antennae reaching almost the tip of abdomen. Both nymphs and adults congregate closely on tender rootlets

Received in March, 1996.

*Corresponding author

and suck plant sap. Their number was very large thus giving the rootlets an appearance of twisted strings of pearls.

The mealy bug was associated with a small yellowish brown ant, *Acropyga acutiventris* Roger (Hymenoptera: Formicidae). The ants actively carried the nymphs and females in their mandibles to safety of deeper layers of soil when roots were exposed to examine the mealy bugs. The mealy bugs were also found in the nests of the ant. Silvestri (1924) reported this mealy bug on roots of *Ficus obtusa* and also the association with *A. acutiventris*. A blind white isopod was also associated with the mealy bug and the ant. Chopra (1924) has described the isopod as *Platyarthrus acropyga* Chopra associated with the mealy bug in Barkuda Island. Williams (1978) described the morphology, habits and discussed the taxonomy of the 12 anomalous ant attended mealy bugs from southeast Asia under six genera including *Xenococcus*. Mention is also made about the first instar of *X. annandalei* collected on coconut, *Cocos nucifera* L. sent from Mysore as early as 1937 (Williams, 1978). An unusual occurrence of the female "pupal" stage was also described by Williams (1986). Apart from India, this mealy bug is known to occur in Malaysia (Malaya, Penang), Vietnam (Thana-hoa), Hong Kong (Repulse Bay) and Indonesia (Sulawesi) (Williams, 1978, 1986). However, it has not so far been reported as a pest of grape vine.

In addition to grape vine, *X. annandalei* was also found feeding on roots of *Oxalis latifolia* H. B. (Oxalidaceae), *Euphorbia hirta* L. (Euphorbiaceae), *Blepharis mollinginifolia* Pers. (Acanthaceae) and *Ageratum conyzoides* L. (Asteraceae) growing as weeds in the grape garden.

ACKNOWLEDGEMENTS

We are grateful to Dr. D. J. Williams, The Natural History Museum, London for the literature and confirming the identity of the mealy bug and the ant and to Mr. T. M. Musthak Ali and Dr. Syamsundar Joshi, University of Agricultural Sciences, Bangalore for identifying the ant and the plant species, respectively.

REFERENCES

Chopra, B. (1924). The fauna of an island in the Chilka lake, on two myrmecophilous isopods from Barkuda. *Rec. Indian Mus.* **26**: 523–528.

Mani, M. (1989). A review of pink mealy bug, *Maconellicoccus hirsutus* (Green). *Insect Sci. Applic.* **10**: 157–167.

Nair, M. R. G. K. (1986). *Insects and mites of crops in India.* viii+408 pp. 2nd Ed. Indian Council of Agricultural Research, New Delhi.

Silvestri, F. (1924). A new myrmecophilous genus of Coccidae (Hemiptera) from India. *Rec. Indian Mus.* **26**: 311–315.

Williams, D. J. (1978). The anomalous ant-attended mealy bugs (Homoptera: Pseudococcidae) of south-east Asia. *Bull. Br. Mus. nat. Hist. (Ent.)* **37**: 1–72.

Williams, D. J. (1986). Unusual instrars in *Xenococcus annandalei* Silvestri (Homoptera: Pseudococcidae). *Boll. Lab. Ent. Agr. Filippo Silvestri*, **43** (Suppl.), 73–77.

BOOK REVIEW

False Spider Mites Infesting Crops in India by G. L. Sadana, Kalyani Publishers, Ludhiana, New Delhi, Noida (U.P.), Hyderabad, Madras, Calcutta, Cuttack, Price Rs.150, pp. 201.

The false spider mites which come under the family Tenuipalpidae infest almost all types of plants and some are well known pests of crops causing substantial losses in yield. This book is a compilation of the vast literature accumulated during the last decades (1876-1991). The book highlights the economic importance, number of species, host range, distribution, biology, ecology and keys to the Indian species of false spider mites.

The book has eight chapters with a preface by the author. Besides, an introductory chapter, references and index to the genera and species of mites and host plants are also given. The first chapter gives a historical resume on the taxonomic status of the family separating it from the family Tetranychidae. The second chapter enumerates the habit and habitat, mode of feeding and damage symptoms, mating behaviour, oviposition, life table parameters, influence of weather parameters on population levels, host plant susceptibility etc. which will be much educative to the beginners in the field of acarology, particularly on false spider mites. The third chapter gives an illustrative account on the general morphological characters and terminology used for the identification of the false spider mites. The fourth chapter gives taxonomic description of the tenuipalpid mites, keys to the species under each genera and enlists 12 genera and 80 species of Indian false spider mites. The illustrations given in the text are really useful and are of good quality. No uniformity was observed in the species name given in the key and this may be corrected in the revised edition of the book.

The book is an excellant treatise on the taxonomy of the Indian false spider mites. The author deserves the gratitude and appreciation of all the acarologists for this masterly presentation.

B. Sathiamma
CPCRI, Regional Station, Kayangulam
Krishnapuram 690533, Kerala

Entomon 22(2): 169–172 (1997)

Professor K. J. Joseph at Seventy–One: An Appreciation

U. C. Abdurahiman,[1] T. C. Narendran,[1]* M. A. Haq,[1] P. J. Joy,[2] Kurian Raphael[3]

[1]*Professor, University of Calicut;* [2]*Professor, Kerala Agricultural University;* [3]*Research Officer, Central Coffee Research Institute*

Professor K. J. Joseph who retired from service as Senior Professor and Head of the Department of Zoology, University of Calicut, in 1987, attained the age of 70 years on 20th May 1997. Born in Kottayam as the third child of Professor K. M. Joseph and Mrs. Annamma Joseph, he had his early education at the St. Joseph's High School, Trivandrum. He took his Degree in Zoology at the Maharajah's College (University College), Trivandrum (1947) and his Master of Science Degree in Zoology with specialisation in Entomology, at the St. John's College, Agra (1950). Thereafter he joined for research at the School of Entomology in the same college (1950–'53), before proceeding to Paris to continue his research. In 1958 he was awarded the Doctor of Science Degree in Entomology of the University of Paris, with High Honours citation.

Back in India, Professor Joseph held the following posts with competence and distinction: Reader and Head of the Department of Zoology, Karnatak University, Dharwad (1959–'63); Reader in Zoology, University of Kerala, at its Calicut Centre (1963–'68); Professor of Zoology and Head of the Department, University of Calicut (1969–'87). From 1978–'80, Professor Joseph was deputed on foreign assignment to serve the university of Basrah, Iraq, as Professor of Entomology.

Because of the very wide exposure Professor Joseph had both in India and abroad, he has been able to carry out research and guide doctoral students in several areas of Zoology. He was introduced to the study of the little known group of fig-wasps (1950) by his teacher, Professor M. S. Mani, one of the most distinguished Indian Entomologists and Director, School of Entomology, St. John's College, Agra. He made extensive collections of the fig-wasps from several regions of India and published taxonomic descriptions and biological accounts of many new genera and species belonging to the *Agaonidae, Torymidae, Pteromalidae* and *Eurytomidae* (Chalcidoidea).

Received in January 16, 1998.

*Corresponding author

The above publications attracted the attention of Professor P. P. Grasse, Director, Laboratory d' Evolution, University of Paris, who extended an invitation to Professor Joseph to work in his laboratory in Paris. The award of a French Govt. Scholarship enabled Professor Joseph to work in France (1954–'58) on the detailed biology of *Blastophaga psenes* (L.) (the *trypesis caricae* (L.), clearly demonstrating for the first time, the cleptoparasitic relationship between the parasite and its host. Since then, Professor Joseph and his associates have made significant contributions to our knowledge of the fig-wasps from India, viz., the discovery of many more new genera and species, the revision of their classification, the study of their biology, behaviour and inter-relationships, their biosystematics, unisexual variations and polymorphism, their adaptations to life inside the fig syconia, their role in fig pollination, their reproductive strategies, and the very interesting discovery of a new species of agaonid, *Camerothorax bimasculinus* (Joseph) having two distinct types of males (one type with fully developed wings and possessing the female pattern of body configuration; the other type fully apterous, with vermiform body), and the significance of the evolution of this extremely rare phenomenon.

The publications related to the above-mentioned work on Fig-Chalcidoidea were appreciated by the Insect Identification and Parasite Introduction Branch, United States Department of Agriculture, Washington D. C., and in 1966, Professor Joseph was invited to take up a research project on the Taxonomic Studies of the Oriental Species of *Brachymeria (Chalcididae: Hymenoptera)*. The genus *Brachymeria* includes the most common and widely distributed species of the family *Chalcididae*, many species being primary parasites of many of our important pests of agriculture. Under this project, 21 new species and 7 new subspecies were described, and revisions of 43 known species made. The results of the work were published in Indian and international research journals. The taxonomic part of the work, with a key to the Oriental Species of *Brachymeria*, was published as a Monograph authorised by K. J. Joseph, T. C. Narendran and P. J. Joy; 215 pp. (1973). This project work also showed that in the natural biological control of the black-headed caterpillar pest (*Opisina arenosella*) of coconut in Kerala, 6 species of *Brachymeria* are actually involved, whereas it was earlier thought that only 1 species (*B. nephantidis*) was implicated.

Professor Joseph's close association with Professor P. P. Grassé (one of the greatest termitologists and sociobilogists, and founder of the international journal "Insectes Sociaux") influenced him to undertake studies in India on the organisation, biology, reproduction and architecture of termites, on their flagellate symbionts, on their termitophiles (1960–'64) and on the biology, reproduction and behaviour of the social spider *Stegodyphus sarasinorum*, and on the binomics and life-history of its commensalistic *Embioptera* (1970–'77).

At the request of three cardamom estates in the Mickimalai area of Wyanad district, Kerala, the extensive outbreak of hairy caterpillars (*Eupterote* spp.) as serious pests of cardamom in 1981–'82, was investigated and recommendations given for its integrated management (*Tropical Pest Management*, 1983). Large-scale outbreak of the spotted locusts (*Aularches miliaris*) took place as very serious defoliators of cardamom plants in 3 estates in Idukki district, Kerala, in 1983. The problem was studied in depth and recommendations given for the integrated management of this pest (*Proc. 2nd Intern. Conf. Plant Protection in the Tropics*, Kaula Lumpur, 1986).

In the area of insect behaviour, the following studies were undertaken (i) the roosting behaviour of the solitary sphecid wasp *Chalybion bengalense* and its significance (1982); (ii) the reflex forth-discharging behaviour in the spotted locust (*Aularches miliaris*) as an anti-predator behaviour in the dragonfly *Potamarcha congener* and its significance (*Adv. Odonatology*, 1989); (iv) the nesting and provisioning behaviour of the potter wasp (*Delta conoides*) and the ethological analysis of the behaviour (1991).

The biology, ecology, behaviour and life-history of the elephant-dung beetle (*Heliocopris dominus: Scarabaeidae*), requiring field work in the wild elephant habitats of Nilambur forests, were investigated (1988-'91). The mechanism of sound production in the males and females of *H. dominus* was studied in the light of the scanning electron micrographs of their stridulatory organs and the significance of the sound production proposed (1991). The problem of sexual dimorphism and intra-sex variations in *H. dominus* was clarified definitively (1994).

From his study of the stridulatory organs and the mechanisms of sound production in insects, Professor Joseph went on to take up research on communication through the production of sounds (bioacoustics) in insects and birds and to ornithological research. In 1971 he had a short training in research methods in Bioacoustics and Ornithology at the Animal Sound Archives of the Hungarian Academy of Sciences, Budapest. Some significant work done in these areas are: (i) the male calling song in the big brown cricket (*Brachytrypes portentosus: Gryllidae, Orthoptera*) and the structure of its stridulatory apparatus (1972); (ii) birds control by alarm signals (1975); (iii) vocalisations of the black drongo (*Dicrurus adsimilis*) and of the red-vented bulbul (*Pycnotus scaber*) (1977); (iv) equipment and techniques in recording bird sounds (1978); (v) the very first scientific paper in India on: "Ecological Strategies for Reducing Bird Hazards to Aircraft, with special reference to India" (1977).

Bio-ecological studies on the *Odonata* (dragonflies and damselflies) of the rice-farming Kole Wetlands of Central Kerala have convincingly shown that at least 10 genera and species of dragonflies and 2 genera and species of damselflies actively predate on many of the major and minor pests of rice. Of the above, the dragonfly *Pantala flavescens* which is the most abundant and widespread, is the most effective predator on account of its feeding in aggregations of from 50–200 individuals, flying round and scouring practically every cubic inch of space above the paddy fields (1992–'94). Field observations of infestation by *Heteropsylla cubana* on subabul cultivation in the Dhoni Farm (Palakkad dist.) showed that the same dragonfly species (*P. flavescens*) is the most important natural enemy of these psyllids. Large feeding aggregations of this species were found to systematically predate on the psyllids during their period of maximum population build up. Individual dragonflies in hovering flight very close to the subabul shoots, appeared to create air currents below, capable of flushing out some of the adult psyllids which were then predated upon (1993–'94). The above are the first two cases from India of the sustained predation of any agriculturally important pest species by dragonflies. It was therefore proposed that it is high time that we revised the status given to the *Odonata* by Fraser (1933) as "scavengers of the atmosphere, destroying noxious flies and mosquitoes as well as the smaller moths which are considered pests," to the higher status of economically very important opportunistic predators and take adequate steps for conserving the species diversity and abundance of our valuable odonate resource (1933; 1996).

Till date, Professor Joseph has 125 publications (2 books; 105 technical papers in Entomology, 5 on social spiders and their commensals, 8 in Bioacoustics and Ornithology; 5 popular articles on aspects of Environmental and Wildlife Conservation). He convened the First National Seminar on Entomophagous Insects and Other Arthropods and their Potential in Biological Control, and published its proceedings: "Advances in Biological Control Research in India" (Eds. K. J. Joseph and U. C. Abdurahiman; 258 pp.) (1987). Twelve of Professor Joseph's research associates have been awarded the Ph.D. Degree in Zoology (9 in Entomology, 1 in Protozoology, 1 in Arachnology and 1 in Ornithology). As a university teacher, Professor Joseph was enthusiastic in postgraduate teaching and has inspired generations of students.

Professor Joseph has numerous professional affiliations. He is a Fellow of the Entomological Society of India; a past Fellow of the Royal Entomological Society of London; Life Member of the Association for the Advancement of Entomology and a past Member of the Editorial Board for Entomon; past Member, Editorial Board for *Bioacoustics*, the international journal for recording and study of animal sounds. He has served several University Bodies and Universities in various capacities: Dean, Faculty of Science, Member of Senate, Chairman of the Postgraduate Board of Studies in Zoology (University of Calicut); Member, General Council (Kerala Agricultural University); Expert Member for Zoology (U. G. C. Visiting Committee for Aligarh Muslim University, University of Mysore, Mangalore University); Member, Academic Council (Cochin University of Science and Technology); Member of Selection Committees (U. P. S. C. and C. S. I. R.); Member, Board of Examiners in Zoology for Ph.D., M.Sc. and B.Sc. (Madras, Annamalai, Karnatak, Marathwada and Kerala Universities).

Since June 1987, Professor Joseph is settled in "Hill Gardens" Colony in Thrissur. From January 1988 for 6 years, he was appointed as Professor Emeritus and Principal Investigator (Projects) in the Department of Entomology, College of Horticulture, Kerala Agricultural University, Thrissur. His research projects there on the eumenid wasps, the elephant dung beetles and the odonates were funded by the U. G. C. and the S. T. E. C. (Kerala). Professor Joseph retired from active research in December 1995 to establish the "Institute of European Languages" at Thrissur, under the auspices of which, as Chairman of the Institute, he coordinates its "Translation Services," and as Consultant in French, he teaches various courses in French language for college students and for working personnel.

On this occasion, we, his former research associates and colleagues, fondly and respectfully pay our homage to Professor Joseph. It is with great pleasure that we record here our sincere appreciation and esteem for his great qualities of heart and soul, his organising abilities, his commitment to teaching and research, his scholarship and erudition, and his honesty, integrity and simplicity of character, which endeared him to all. He can look back with pride and satisfaction about his manifold achievements. We wish Professor Joseph health and happiness, and all success in his present endeavour.

The Professor
T. N. Ananthakrishnan Award
1997-1998

Instructions

1. Former or present Vice-Chancellors of Universities/Principals of Colleges/Directors of Central or State or Private research institutions/Heads of Departments not below the rank of full professors can nominate suitable candidates for the award.
2. Nominee should **not have crossed 40 years of age as on 31 December 1997**.
3. The award will be made to any Indian citizen for his/her contributions to Entomology based on the work done in India.
4. A 500-word note justifying why the nominee deserves the award is important. Its absence will invalidate the nomination.
5. All the requested details as in the format should be provided on A-4 size white paper.
6. Four sets of publication of the nominee made in the last 10 years in support of nomination should accompany the nomination papers.
7. An independent jury consisting of three eminent entomologists of India, constituted by the Trustees of the Foundation, will evaluate the nominations and select the awardee. The jury's decision will be final.
8. **The award consisting of Rs.5,000/- in cash, a silver plaque, and a citation** will be presented in a simple public ceremony on Monday, the 31 March 1998 (The venue will be notified later).
9. Complete nominations with all enclosures must reach the Secretary (Professor M. C. Muralirangan) of the Foundation (address given on the cover page) on or before Friday, the 16 January 1998.

Format for Nomination
(Please use separate a-4 size white paper and type)

I _____ (Name, designation, and official address of the Nominator) nominate _____ (Name, designation, and full address of the nominee) for the Professor T. N. Ananthakrishnan Award of 1997-98. His/her curriculum vitae and four sets of publications made by him/her in the last 10 years are enclosed.

He/she deserves the award because _____ (complete the statement explaining and justifying the motivation, effort, sustenance, and achievements of the nominee in about 500 words

Station Signature

Date Official Seal

Curriculum Vitae of the Nominee

1. Full Name:
2. Official Address:
   (Include PIN code and telephone/telefax numbers, if available)
3. Residential Address:
   (Include PIN code and telephone/telefax numbers, if available)
4. Date of birth:
   (Provide age proof as Appendix I)
5. Academic qualifications:
6. Honours and Awards:
7. Area of specialization within Entomology:
8. List of publications:
   (from the beginning to date; but send only 4 sets of those papers made in the last 10 years, as Appendix 2).
9. A brief note (500 words) on your research achievements.

The Professor T. N. Ananthakrishnan Foundation
C/o G. S. Gill Research Institute
Guru Nanak College
Chennai 600 042

Tel: (044) 2451746

Fax: 91-131-432453

CALL FOR PAPERS

Publisher is pleased to announce a new Scientific Journal
"JOURNAL OF EXPERIMENTAL ZOOLOGY, INDIA"
(An International Journal)
First Issue of Journal appearing in January 1998

All types of queries and manuscripts
may be submitted to:

Dr. P. R. Yadav
Editor-in-Chief
Department of Zoology
D. A. V. (P. G.) College
(Ch. C. S. University)
Muzaffarnagar - 251`001, India

Reg. No. R. N. 29386/76

Published by D. Muraleedharan and typeset in TEX by River Valley Technologies, Trivandrum and printed at Solar Offset Printers, Trivandrum for the Association for the Advancement of Entomology